Economic Analysis of Air Pollution Regulations: Miscellaneous Organic Chemicals (MON)

Final Report

Prepared for

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Office of Air Quality Planning and Standards
Innovative Strategies and Economics Group (ISEG)
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SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is developing a maximum achievable control technology (MACT) standard to reduce hazardous air pollutants (HAPs) from the coatings manufacturing and chemical manufacturing source categories. EPA estimates that 370 facilities produce miscellaneous organic NESHAP (MON) products, including 207 that produce MON organic chemicals using batch processes, 140 that produce MON chemicals using continuous processes, and 127 that produce MON coatings. Of the 370 facilities, 64 use both batch and continuous processes to produce organic chemicals; 15 produce both coatings and continuous-process MON chemicals; 12 produce both coatings and batch-process organic chemicals; and two produce coatings, batch-process chemicals, and continuous-process chemicals.

To support EPA's development of the MACT standards, hereafter referred to as the Miscellaneous Organic NESHAP or MON, EPA's Innovative Strategies and Economic Group (ISEG) has conducted an economic impact analysis (EIA) to assess the potential costs of the rule. This report documents the methods and results of this EIA.

1.1 Agency Requirements for an EIA

Congress and the Executive Office have imposed statutory and administrative requirements for conducting economic analyses to accompany regulatory actions. Section 317 of the CAA specifically requires estimation of the cost and economic impacts for specific regulations and standards proposed under the authority of the Act.[1] ISEG's *Economic Analysis Resource Document* provides detailed instructions and expectations for economic analyses that support

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[1]In addition, Executive Order (EO) 12866 requires a more comprehensive analysis of benefits and costs for proposed *significant* regulatory actions. Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is required only when the regulatory action has an annual effect on the economy of $100 million or more. Other statutory and administrative requirements include examination of the composition and distribution of benefits and costs. For example, the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement and Fairness Act of 1996 (SBREFA), requires EPA to consider the economic impacts of regulatory actions on small entities.

rulemaking (EPA, 1999a). In the case of the Miscellaneous Organic NESHAP, these requirements are fulfilled by examining the effect of the regulatory alternatives on the following:

- market-level impacts,
- industry-level impacts, and
- societal-level impacts.

1.2 Summary of EIA Results

The proposed MON rule will impose small production costs and therefore generate small economic impacts in the form of small increases in market prices and decreases in MON chemicals and coatings produced. The impacts of these price increases will be borne largely by other manufacturers that use the MON chemicals as inputs and to some extent by some domestic producers in terms of lower profits. The behavioral responses and adjustments by consumers and producers to changes in market conditions will ensure that, by and large, the social costs of the regulation are lower than the pure financial or "engineering" costs. The key results of the EIA for MON are as follows:

- *Engineering Costs*: Total annual costs measure the costs incurred by affected industries annually. Batch producers of organic chemicals incur the largest share, approximately $55.9 million, while continuous producers of organic chemicals incur an estimated $22.3 million, and coating manufacturers incur an estimated $16 million. The average annual costs for the chemical manufacturers totaled $78.2 million.
- *Price and Quantity Impacts*: These impacts are small.
  - The average prices for MON chemicals and coatings are projected to increase by less than 0.5 percent, or less than $0.01 per pound.
  - The quantity of regulated coatings is estimated to decline by 3.7 million pounds, and the quantity of MON chemicals is estimated to decline by approximately 36 million pounds. Both of these declines represent less than 0.2 percent of baseline production.
- *Small Businesses*: EPA performed a screening analysis for impacts on small businesses, by comparing compliance costs to baseline company revenues. Of the 148 companies owning MON chemical facilities, EPA estimates that 12 businesses, all small businesses, will incur costs exceeding 1 percent of baseline sales.

- *Social Costs*: The economic model estimates a slightly smaller total social cost of the rule of $94.1 million. Consumers (domestic and foreign) are projected to lose $62.8 million, and directly affected producers lose $31.5 million. (Note that in the case of the market for MON commodities, consumers are generally other producers of intermediate or final goods.) Within the coatings sector, EPA estimates that eight businesses, including seven small businesses, will incur costs to comply with MON that exceed 1 percent of their baseline sales. Of the 148 companies owning MON chemical facilities, EPA estimates that 12 businesses, all small businesses, will incur costs exceeding 1 percent of baseline sales.

1.3 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA of the Miscellaneous Organic NESHAP.

- Section 2 presents a profile of the affected industry.
- Section 3 describes the estimated costs of the regulation.
- Section 4 describes the EIA methodology and reports market-, industry-, and societal-level impacts.
- Section 5 presents estimated impacts on companies owning MON facilities, including small businesses.
- Appendix A provides a description of the operational model used to develop quantitative estimates of the economic impacts.
- Appendices B, C, and D report the results of sensitivity analyses of impact estimates to changes in key model parameters.
- Appendix E includes results from the initial screening analysis performed to estimate economic impacts and inform the development of the economic model.
- Appendix F is a profile of the affected industry segments.

SECTION 2

INDUSTRY PROFILE

The proposed MON rulemaking will affect facilities and companies producing miscellaneous organic chemical products and coatings. EPA's data do not permit clearly identifying the marketed commodities produced by these facilities or the production processes used. EPA is able to determine the general types of products produced, based on the Standard Industrial Classification (SIC) code identified for each facility. This section summarizes profiles of several industries as identified by their SIC codes. These SIC codes represent the industries for the majority of potentially affected facilities. The detailed SIC code profiles are provided in Appendix F.

SIC codes potentially affected by the MON rulemaking include the following:

- 2851 Paints and Allied Products,
- 2865 Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments,
- 2869 Industrial Organic Chemicals, Not Elsewhere Classified,
- 2841 Soaps and Other Detergents,
- 2842 Polishes and Sanitation Goods,
- 2843 Surface Active Agents,
- 2873 Nitrogenous Fertilizers,
- 2874 Phosphatic Fertilizers,
- 2875 Mixing-Only Fertilizers,
- 3861 Photographic Equipment and Supplies,
- 2891 Adhesives and Sealants,

- 2893 Printing ink,
- 2899 Chemical Preparations,
- 2824 Organic Fibers, and
- 2821 Plastic Materials, Synthetic Resins, and Nonvulcanizable Elastomers.

To understand the context for the regulation, EPA prepared industry profiles for related groups of these SIC codes. Appendix F contains these eight profiles. The industry groups for which profiles were prepared are shown in Table 2-1.

Table 2-1. Industry Groups Profiled and Related SIC Codes

Industry Group	Related SIC Codes	NAICS Codes
Paints and Allied Products	2851	32551
Industrial Organic Chemicals	2865, 2869	32511, 325132, 325192, 325188, 325193, 32512, 325199
Soaps and Cleaners	2841, 2842, 2843	325611, 325612, 325613
Agricultural Chemicals	2873, 2874, 2875	325311, 325312, 325314
Photographic Equipment and Supplies	3861	333315, 325992
Adhesives, Sealants, and Printing Ink	2891, 2893, 2899	32552, 32591, 32551, 31942, 325199, 325998
Organic Fibers (Noncellulosic)	2824	325222
Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers	2821	325211

The following eight sections provide short summary profiles of these industry groups. Section 2.9 describes the organization of the MON industries and summarizes data on regulated facilities based on EPA’s database.

2.1 Paints and Allied Products

The paint and allied products industry is relatively small when compared to other manufacturing industries. In 1997, the sector (SIC 2851, NAICS 32551) shipped $19,221.7 million dollars worth of products. All dollar values are 1998 dollars unless otherwise indicated. This industry supplies essential products to major manufacturing and consumer industries from automobiles to home furnishings.

Typical products manufactured by the industry include paints (ready-made and paste), varnish, lacquers, enamels and shellac putties, wood filters and sealers, paint and varnish removers, paint brush cleaners, and other allied paint products.

Three market segments account for the vast majority of output: architectural coatings (SIC 28511), original equipment manufacturer (OEM) product coatings (SIC 28512), and special purpose coatings (SIC 28513). While SIC 2851 grew 16.4 percent over the period 1987 to 1995, architectural coatings grew 20.9 percent, OEM grew 18.2 percent, and special purpose coatings grew 24.0 percent in real terms. Overall, despite the recession in the early 1990s, the value of shipments increased 25.8 percent from 1987 to $19,221.7 million in 1997.

Architectural coatings accounted for 33.7 percent of this industry's total value of shipments in 1995. Commonly referred to as house paint, the architectural coatings sector generates nearly half of the industry's revenue. In 1995, sales of OEM constituted 29.3 percent of the industry's total value of shipments. OEM products are often custom formulated to meet applications specified by the end user. Primary users of OEM paints are automobile, appliance, equipment manufacturing, and furniture industries. Special purpose coatings shipments amounted to 17.3 percent of the 1995 industry receipts. While similar to architectural coatings in that this sector could be classified as stock or shelf goods, the special purpose coatings sector formulates its product for specific applications and/or environmental conditions and typically sells directly to the end user. The primary markets for its products are automotive, machine refinishing, industry maintenance, bridge and traffic markings, and marine.

2.1.1 Supply Side of the Industry

2.1.1.1 Production Processes

Paints primarily comprise pigments, resins, and solvents. The industry purchases the majority of its inputs from other manufacturers in the chemical industry (SIC 28). Most paints comprise four basic groups of chemical raw materials: binders and resins, pigments and extenders, solvents, and additives. When a paint is applied to a surface, the solvents begin to evaporate while the binder, pigments, and additives remain on the surface and harden to form a solid film. The chemical and physical properties of paints are directly related to the choice and concentration of raw materials determined during the production process. Paints are divided into two categories: water- and solvent-based paints and powder paint.

2.1.1.2 Types of Output

The various products produced by the paint and allied products industry can be divided and described as follows:

- Architectural coatings: Protective and decorative coatings applied onsite to the interior or exterior surfaces of industrial, commercial, institutional, or residential buildings for ordinary use and exposure. Architectural coatings include clear finishes and spar varnishes, enamels, primers, paints, stains, and lacquers.

- OEM coatings: Coatings designed specifically for an OEM to meet application and product requirements to be applied during the manufacturing process. OEM coatings include both powder coatings and electrical insulating coatings.

- Special purpose coatings: These coatings differ from architectural coatings in that they are formulated for special applications and/or environmental conditions such as extreme temperatures, chemicals, and fumes. Types include:

  – industrial new construction and maintenance paints,

  – marine paints including ships and offshore facilities,

  – traffic paints,

  – refinish paints, and

  – aerosol paints.

2.1.1.3 Costs of Production

The inputs for paints and allied products include various resins, solvents, pigments, extenders, binders, and other additives. In constant 1998 dollars, the cost of materials rose 27 percent over the period 1987 to 1997 to $9,948 million. The higher cost of materials reflects the changing content of paint products. The use of higher solids content and environmental concerns necessitated using more expensive ingredients and using epoxies in paint. Prices for acetone, benzene, chlorine, and fiber-grade increased; however, phenol prices remained steady. The increasing cost of raw materials has been a concern for the industry.

The amount of labor employed by the industry dropped from 55,200 in 1987 to 52,700 in 1997, while the industry's payroll increased by $289.5 million (1998 dollars), indicating that the manufacturing process became increasingly mechanized and required skilled labor. In 1992, energy costs were $129.4 million, which is a 1.02 percent increase over 1992 figures.

2.1.1.4 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of the actual operations to the full production levels. From 1993 to 1998, the capacity utilization rates fell from 67 to 59 percent. Capacity utilization rates typically fall near 70 percent for the industry.

2.1.2 Demand Side of the Industry

Modern chemistry has produced coatings that add aesthetic value and are also resistant to natural elements, or electrical conduction, or wear and tear by vehicles. The paint and allied products industry is able to formulate a coating to fulfill almost any request a client may have. In the last 20 years, the industry has made major advances in the durability and quality of coatings.

The coatings industry is essential to nine other major U.S. industries: automobiles, trucks and buses, metal cans, farm machinery and equipment, construction machinery and equipment, metal furniture and fixtures, wood furniture and fixtures, major appliances, and coil coating (high speed application of industrial coatings to continuous sheets, strips, and coils of aluminum or steel) (U.S. Department of Commerce, 1995f).

There are few substitutes for coatings. Within the industry, the 20 percent growth of powdered paints in the 1980s quelled the demand for liquid products. Powdered paints are popular because of environmental concerns.

2.1.3 Organization of the Industry

2.1.3.1 Firm Characteristics

In 1997, the majority (61 percent) of facilities producing paints and allied products were small facilities with fewer than 20 employees. However, these facilities contributed only 8.2 percent to the total value of shipments. In 1992, the five largest coatings companies accounted for 31.1 percent of 1992 sales of coatings.

Based on concentration ratios and the Herfindahl-Hirschmann index (HHI), paints and allied coatings is not a concentrated industry. This indicates that the paint and allied products market is fairly competitive.

2.1.3.2 Geographical Distribution

Facilities involved in the coatings industry are concentrated in states with heavy involvement in manufacturing. Ohio, California, and Illinois alone accounted for 35.3 percent of the total value of shipments and 33 percent of total employment in the industry.

2.1.4 Markets and Trends

There has been mild growth in the percentage of domestic production of paints and allied products being exported. Domestic consumption of paints and allied products increased by 10.7 percent, while domestic production increased by 14.1 percent over the period 1987 to 1994.

2.2 Industrial Organic Chemicals

SICs 2865 and 2869 are divisions of the greater Industrial Organic Chemicals category, representing cyclic crudes and intermediates and industrial organic chemicals not elsewhere classified (N.E.C.), respectively. These are major sectors within the U.S. chemical industry, and had a combined annual value of shipments of $83,323.4 million ($1998) in 1997. All values in this report are in 1998 dollars.

Products produced by cyclic crudes and intermediates are divided into three sectors. First, the aromatic chemical production sector produces benzene, toluene, mixed xylenes, and napthalene. The second and third sectors produce synthetic organic dyes and synthetic organic pigments, respectively. Dyes are colored substances that are fully soluble in the vehicle or medium. Pigments are colored, colorless, or flourescent finely divided solids that are usually insoluble in (and unaffected by) the vehicle or medium in which they are placed. Both provide color by absorbing or reflecting selected light rays.

The cyclic crudes and intermediates industry was affected by the early 1990s' recession. In 1989, the value of shipments reached $10,657.1 million but fell to $10,409.3 million in 1992. The industry began to recover and shipped $12,264 million worth of goods in 1997, an increase of nearly 17.9 percent over 1987's value.

The miscellaneous industrial organic chemicals group includes establishments producing chemicals that cannot be classified in other SIC categories. Product groupings range from chemical warfare gases to synthetic perfumes and flavoring chemicals. This industry suffered from the same recessionary effects as SIC 2865, although in terms of percentages, the effects were not as significant. In 1997, its shipments were valued at $71,059.4 million, an increase of 40 percent over 1987's value.

2.2.1 Supply Side of the Industry

Production processes vary, but generally involve reacting (through a variety of methods) raw materials and chemicals together in vats or tanks to form a product, then cooling, refining, and for solids, drying, and packaging. Between the 1992 and the 1997 Census of Manufactures, expenditures on new capital in the dyes and pigments industry increased from $17.5 billion to $19.2 billion (U.S. Department of Commerce, 1995f; U.S. Department of Commerce, 1999h; U.S. Bureau of Labor Statistics, 2000).

2.2.1.1 Major By-products and Co-products

The chemical industry produces a significant amount of waste. Even a small amount of discharge is noticeable because of the color or aroma of the emissions. For environmental and public health reasons, facilities clean their waste before discharge. Acidic and alkaline liquors are neutralized, and the waste is filtered to remove heavy materials before leaving the facility.

2.2.1.2 Types of Output

Dyes and pigments are available in a variety of forms: dry powders (both surface treated or untreated), presscakes, flushed colors (thick pastes), fluidized dispersions (pourable), resin predispersed pigments, and plastic color concentrates or master batches (granules). Pigment types include azo pigments, lakes, copper phthalocyanines, quinacridones, diaryl pyrrolopyrroles, and dioxazine.

Aromatic chemicals include products such as benzene and toluene. Cyclic crudes include light oils and light oil products and products of medium and heavy oil such as napthalene.

Miscellaneous industrial organic chemicals comprise nine general categories of products:

- aliphitic and other acyclic organic chemicals (ethylene); acetic, chloroaceptic, adipic, formic, oxalic, and tartaric acids and their metallic salts; chloral, formaldehyde, and methylamine;
- solvents (ethyl alcohol etc.); methanol; amyl, butyl, and ethyl acetates; ethers; acetone, carbon disulfide and chlorinated solvents;
- polyhydric alcohols (synthetic glycerin, etc.);
- synthetic perfume and flavoring materials (citral, methyl, oinone, etc.);
- rubber processing chemicals, both accelerators and antioxidants (cyclic and acyclic);
- cyclic and acyclic plasticizers (phosphoric acid, etc.);
- synthetic tanning agents;
- chemical warfare gases; and
- esters, amines, etc., of polyhydric alcohols and fatty and other acids.

2.2.1.3 Costs of Production

Cyclic crudes and intermediates have long been a mature industry. Until 1996, employment varied little, holding steady at an average of 23,000 workers for the years 1987 to 1996. However, between 1996 and 1997, employment fell by 15 percent. Payroll remained around the same level during this period. It is notable that while the level of employment in the industry fell by 15 percent between 1996 and 1997, the payroll increased by almost 37 percent. The cost of materials does appear to trend upward, but only slightly. The cost of materials only increased 7.4 percent between 1987 and 1997. New capital investment averaged $724.8 million per year.

Employment in miscellaneous organic chemicals, SIC 2869 (NAICS 32511, 325188, 325193, 32512, 325199), averaged 97,890 for the 1987 to 1997 time period. Between 1987 and 1994, employment fell 10 percent to 89,800, after a high of 101,000 in 1991. Most jobs lost were at the production level. Facilities became far more computerized, incorporating advanced technologies into the production process. Since 1994, employment in the industry has increased to reach 100,100 in 1997. Even though 1997 employment was about the same as that in 1987, payroll was $1,060.8 million more in 1997 than in 1987. The cost of materials has increased over past years, rising from about $29 billion in 1987 to almost $41 billion in 1997. New capital investment averaged $3,955 million a year.

2.2.1.4 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. The capacity utilization ratio for the cyclic crudes and intermediaries industry and the miscellaneous industrial organic chemicals industry generally range between 80 and 90 percent.

2.2.2 Demand Side of the Industry

2.2.2.1 Product Characteristics

Dyes and pigments are popular for their ability to color materials. Dyes' properties are much the same as pigments, except they are soluble in the vehicle. Pigments are available in varied qualities. Pigments are rated using the following attributes: tinctorial strength, durability, hiding power, transparency, and heat and solvents resistance. Other properties used to judge pigments are brightness (saturation), gloss, rheology, dispersability, crystal stability, bleed resistance, and other properties associated with specialized applications. These attributes vary greatly, from poor to outstanding. Quality depends on the quality of the raw materials and the process and equipment used to create the pigment. Aromatic chemicals are formulated to affect the smell of various products and are used in cosmetics and household products.

Miscellaneous industrial organic chemicals' properties are as varied as the chemicals themselves; some are valued for their ability to affect our foods in a positive manner, others are used in war.

2.2.2.2 Uses and Consumers of Products

Dyes and pigments are used for decorative and/or functional purposes. Pigments and dyes are used in a great many light and durable goods and add aesthetic value to the products into which they are incorporated. Dyes are most commonly used to color polyester and cotton, the two most popular fibers. The textile industry and individual consumers both use dyes. However, the textile industry consumes more dyes in terms of volume and value.

Pigments are used in a variety of products ranging from printing inks to plastics. Pigments have a more varied customer base because of their use in plastics, household products, printing, paints of all kinds, cements, waxes, artist materials, and wall paper (to name a few industries), as well as textiles. The worldwide printing ink industry consumes 41 percent of the total value of pigments, paints 29 percent, plastics 23 percent, and special applications 7 percent (see Figure 2-1).

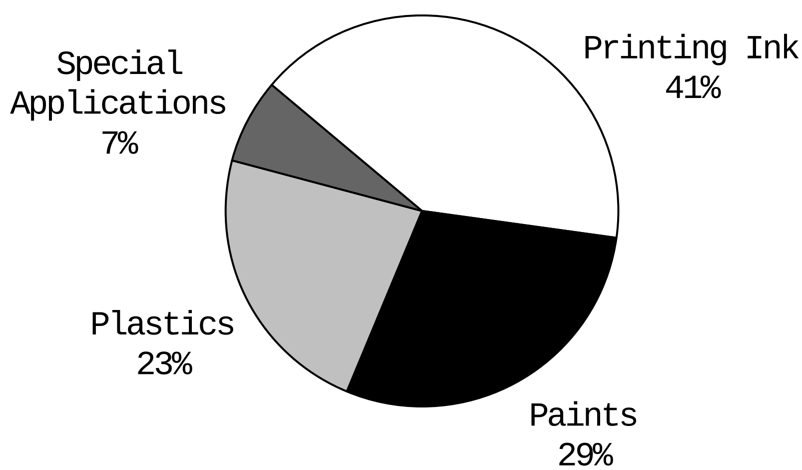

Figure 2-1. Worldwide Pigment Consumption by Industry

Miscellaneous industrial organic chemicals uses and consumers are as varied as their products. Common uses and consumers include food products, plastics additives, the flavor and fragrance industry, and others.

2.2.3 Organization of the Industry

2.2.3.1 Firm Characteristics

Both SIC codes are dominated by large, multinational firms. Many of the largest firms operating in the market are subsidiaries of major European conglomerates, such as Hoechst. In the cyclic crudes and intermediates industry, 150 companies controlled 206 facilities, 143 of which employed more than 20 employees in 1992. In the miscellaneous industrial organic chemicals industry, 489 companies controlled 705 facilities, 428 of which employed more than 20 employees in 1992.

To assess the competitiveness of a market, economists often estimate four- and eight-firm concentration ratios (CR4 and CR8) and HHI. The CR4 and CR8 concentration ratio indicates the percentage of the industry's total sales that is accounted for by its top four (eight) firms. HHI measures indicate that the two industries are relatively unconcentrated. Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices.

2.2.3.2 Geographical Distribution

Companies choose plant locations because of their access to raw materials and proximity to major transportation networks and customers. Available data indicate that, apart from South Carolina, the northern mid-Atlantic states and Illinois dominate cyclic crudes and intermediates production. South Carolina is the state with the largest value of shipments, $864.4 million in 1992. The top five states (by value of shipments) shipped 34 percent of the industry's total value of shipments.

Texas dominates the miscellaneous industrial organic chemicals. Texas alone shipped $26,615.6 million worth of product in 1992, 45.1 percent of the national total. The top five states also include Louisiana, New Jersey, Illinois, and West Virginia. These five states were responsible for 72.1 percent of the nation's total value of shipments in 1992.

2.2.4 Markets and Trends

The market for cyclic crudes, intermediates, and miscellaneous industrial organic chemicals grew steadily through 1989, but then dropped in the early 1990s. The market began rebounding in 1994. From 1987 to 1995, there was a net increase in production of 7.1 percent, while consumption grew by 6.8 percent.

The United States remains an important exporter of organic chemical products, selling nearly $17.2 billion (1998) dollars worth of chemical products to foreign countries in 1995. The chemicals were sold predominantly to NAFTA, the EU, and Japan.

2.3 Soaps and Cleaners

SIC 284 consists of cleaning products, a medium-sized American industry. Soaps and other detergents (SIC 2841), polishes and sanitation goods (2842), and surface active agents (2843) encompass a wide variety of cleaning agents. The largest market served by these industries is the one for bar soap for personal bathing. In 1997, the total value of this industry's shipments was $32,387.3 million. All dollar values are 1998 dollars unless otherwise indicated.[1]

The soap and other detergents industry is nearly twice as large, in terms of value of shipments, as the next largest four-digit SIC code grouping, polishes and sanitation goods. Over the period 1987 to 1997, the soap and other detergents industry grew 21.2 percent in real terms. The industries comprising this SIC produce soap, synthetic organic detergents, and inorganic alkaline detergents in addition to crude and refined glycerin from vegetable and animal fats.

The polishes and sanitation goods industry shipped $8,434.4 million worth of goods in 1997, an increase of 25.3 percent since 1987. Firms engaged in this industry produce polishes for metals and furniture; household bleaches; waxes; and household, institutional, and industrial disinfectants.

The surface active agents industry's value of shipments was fairly steady between 1987 and 1996. In 1997, the industry experienced significant growth, shipping $7,046.6 million dollars worth of product that year, 45 percent more than in 1996. Surface active preparations are used as emulsifiers, wetting agents, and penetrants in soaps and detergents.

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[1]Values adjusted using the plant cost index published in *Chemical Engineering*, various years.

2.3.1 *Supply Side of the Industry*

2.3.1.1 Production Processes

Soap and detergent manufacturing differs depending on the final form of the product: liquid (including gel), powdered, or bar. However, the first step in the manufacturing process, choice of inputs, is similar in theory across all three processes. Soap and allied products inputs are chosen using the following guidelines: human and environmental safety, cost, compatibility with other ingredients, and the form and characteristics of the final product.

The basic ingredients are surfactants(or surface active agents) and builders. Surfactants change the properties of water, effectively reducing the surface tension of water to enable the cleaning solution to wet a surface more quickly so dirt and oils can be more easily and quickly removed. Surfactants also work to keep oils and dirts from settling back into their previous positions.

There are four categories of surfactants, based on their ionic properties: aionic, nonionic, cationic, and amphoteric. Aionic are used in laundry, hand dishwashing, and personal cleansing products. They create the greatest amount of suds. Nonionic surfactants are used in low-suds products such as laundry and dishwasher detergents. Cationic surfactants are used primarily by fabric softening companies. Finally, amphoteric surfactants are used primarily in personal cleansing and cleaning products because their charges change depending on the pH level of the water, making them very flexible.

2.3.1.2 Major By-products and Co-products

The most significant co-product of cleaning products manufacturing is glycerine. Glycerine producers are grouped under SIC 2841. An important industrial material, glycerine is removed from the production line after saponification. It is then treated and refined for use in foods, cosmetics, drugs, and other products.

2.3.1.3 Types of Output

The following products are produced by these industries:

- personal cleaning products: bars, soaps, liquid cleaning products, heavy-duty hand cleaners;

- laundry detergents and aids: liquids, powders, gels, sticks, powders, pastes, sheets, and sprays; bleaches; bluings, enzyme presoaks, fabric softeners, starches, water softeners;

- dishwashing products: automatic detergents, rinse agents, film removers; lime and rust removers;

- household, institutional, and industrial cleaning products and polishes: all-purpose cleansers, abrasive cleansers, clear-surface cleaners, metal cleaners and polishes, tile cleaners, oven cleaners, rug and other surface shampoos, drain openers, and toilet cleaners; and

- cleanser ingredients: wetting agents, emulsifiers, and penetrants.

2.3.1.4 Costs of Production

During the late 1980s and early 1990s, the soaps and other detergents industry (SIC 2841) grew, adding nearly 5,000 workers, an increase of 15.5 percent, between 1987 and 1991.   After the recession, however, the industry begun reducing its quantity of labor inputs. Even though the value of shipments was 21.6 percent higher in 1997 than in 1987, employment was 8.5 percent lower. For the 1987 to 1997 period, payroll rose 3.7 percent and the cost of materials by only 3.3 percent. Energy costs also dropped noticeably during the mid-1990s. New capital investment for the 10 years presented averaged $506.6 million a year.

SIC 2842, polishes and sanitation goods, followed a more conventional pattern from 1987 to 1997. The 25.3 percent increase in the real total value of shipments was accompanied by increases in costs of production. From 1987 to 1997, employment increased 6.7 percent to reach 22,000. Payroll grew to $730.2 million, an increase of 21.3 percent. The largest increase was in the area of raw materials cost; increasing 37.5 percent from 1987 to 1997. Energy costs were $4.5 million higher in 1997 than in 1987. New capital investment averaged $136.3 million a year.

From 1987 to 1995, surface active agents manufacturers, SIC 2843, experienced a general rise in costs, indicating that the 95 percent rise in the value of shipments may not have been accompanied by a commensurate rise in industry profits. In 1997, employment was 4.3 percent higher than in 1987. The payroll was 29 percent higher in 1997 than 1987. Such significant increases in payroll indicate that labor become may have become productive over this time period. Over this same time period, the costs of materials rose by 45 percent. New capital investment averaged $156.2 million over these 9 years. Energy expenditures rose 36.3 percent.

2.3.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. Over the period 1992 to 1997, the capacity utilization rates for the three four-digit SIC codes in this industry have varied widely, from 57 percent to 85 percent. In 1997, capacity utilization was between 60 and 67 percent.

2.3.2 Demand Side of the Industry

2.3.2.1 Product Characteristics

Soaps and allied products can be used to remove dirts and oils from a variety of surfaces including plastic, tile, metal, fabric, concrete, Formica, stone, and wood. More recently, they have been combined with antibacterial elements to disinfect as they clean. Cleaning products can also be formulated to suit a particular consumer's needs.

At the household level, soaps are one of the key components of personal hygiene. In addition to being able to remove dirt and oil off bodies, these products also fight bacteria. They are available in powder, liquid, or solid form, and their versatility in application boosts their popularity.

2.3.2.2 Uses and Consumers of Products

There are four general categories of consumers and users of these products: personal, household, commercial, and industrial. SIC 2843, surfactants, produces intermediate goods used in soaps and polishes. The consumers of these products are the corporations involved with manufacturing products for the consumer groups listed above. Many goods are used by more than one category. For instance, car manufacturers may be industrial consumers when using cleaners during the production process, but they are also institutional users when using these products to clean their offices.

2.3.2.3 Substitution Possibilities

In many respects, no products can substitute for cleaning agents. Within the industry itself, however, liquids, solids, and powders are substitutes. One medium, or vehicle, can substitute for another; however, both individual and industrial consumers purchase more products in liquid and solid form.

2.3.3 Organization of the Industry

2.3.3.1 Firm Characteristics

In the soaps and detergents industry, less than 739 companies controlled 760 facilities in 1997. Only 676 companies controlled 728 establishments. In the surfactants industry, 184 companies operated 211 establishments in 1997. In all three industries, facilities with more than 50 employees produce the majority of product (over 80 percent).

To assess the competitiveness of a market, economist often estimate CR4 and CR8 and HHI. Based on concentration ratios, the soaps and detergents industry appears to be the most concentrated of the three industries studied in this profile. Firms in more-concentrated industries are more likely to be able to influence market prices. In 1992, the HHI for soaps and detergents was 1,584; therefore, the industry is considered to be only moderately competitive. The HHI for polishes and sanitation goods was 817 (i.e., more competitive). The surface active agents industry is also more competitive, with an HHI of 471 (U.S. Department of Commerce, 1995a).

2.3.4 Markets and Trends

2.3.4.1 Production

Between 1987 and 1995, domestic production of soap and other detergent increased by 10.8 percent (in terms of value of shipments) to meet a 7.5 percent increase in domestic consumption, and a dramatic 545 percent increase in net exports. A similar trend was evident in the polishes and sanitation goods industry. Production increased by 19.3 percent between 1987 and 1995, while consumption went up by 18.5 percent, and net exports by 653 percent. Note that net exports appear to increase dramatically because they are small relative to total production. Although production and consumption of surface active agents declined over the same period, production did not decline as much as consumption partly because of strong sales to foreign markets.

2.3.4.2 Consumption

Domestic. Demand for soaps and other detergents has been changing; both household and industrial consumers' preferences have shifted toward liquid products. Analysts at *Chemical Week* project that liquids will soon comprise 50 percent of the market (D'Amico, 1996). Liquid products currently comprise 43 percent of the soap and detergent market. Consumption of surfactants for home use is expected to increase 4.5 percent a year through 2005. Bleaches and other cleaning compounds (SIC 2842) are not predicted to penetrate the U.S. market any further. Although 2.9 percent growth is expected through 2000, the industry is mature. Future growth should match the growth in gross domestic product.

Foreign. In 1996, the United States exported $1.3 billion (in nominal terms) worth of soap, cleansing, and polishing products and preparations. The United States's main trading partners are NAFTA members, the European Union, and East Asia.

2.4 Agricultural Chemicals

Nitrogenous (SIC 2873), phosphatic (SIC 2874), and mixing-only (SIC 2875) fertilizers account for an increasingly large portion of the U.S. agricultural chemical industry's revenue each year. In 1992, the value of shipments of the entire agricultural chemicals industry (SIC 287) was $20,494.5 million in 1998 dollars. The fertilizer industry contributed $11,000.7 million (53.7 percent) to that total; the rest was contributed by agricultural chemicals not-elsewhere-classified (SIC 2879). In 1997, the value of fertilizer shipments was $12,927.2 million in 1998 dollars. The phosphatic fertilizer industry accounted for 45 percent of those shipments. The nitrogenous and mixing-only fertilizer industries accounted for 29 and 26 percent, respectively. Unless otherwise indicated, all values cited in this report are in 1998 dollars.

Companies in SIC 2873, nitrogenous fertilizers, produce fertilizers from nitrogenous materials produced in the same establishment. Manufacturers produce ammonia fertilizer compounds, anhydrous ammonia, nitric acid, ammonium nitrate, ammonium sulfate and nitrogen solutions, urea, and natural organic fertilizers (except compost), and mixtures. Ammonium nitrate, created by reacting nitric acid with anhydrous ammonium, is highly combustible and was for many years the world's most popular fertilizer. But urea with its higher nitrogen content and ability to be stored more safely has eclipsed ammonium nitrate.

Phosphatic fertilizer plants (SIC 2874) produce a host of complementary products such as phosphoric acid; normal, enriched, and concentrated superphosphates; ammonium phosphates; nitrophosphates; and calcium metaphosphates. The most popular phosphatic fertilizer is diammonium phosphate (DAP).

SIC 2875, mixing-only fertilizers, comprises establishments that purchase fertilizer materials and then mix them. Lately, preferences have been shifting away from mixing fertilizers. Some people have argued that mixing fertilizers are inappropriate because they are not adaptable to varying soil quality. Many governments prefer single-nutrient fertilizers applied in appropriate quantities.

2.4.1 Supply Side of the Industry

2.4.1.1 Production Processes

Nitrogenous Fertilizers. Almost all nitrogenous fertilizers are derived from synthetic ammonia. A purified hydrogen-nitrogen mixture undergoes catalytic reaction under high pressure and temperature. The catalyst is specially activated iron. Unreacted gases are recycled, but the ammonia that forms is condensed with liquefied ammonia, creating synthetic ammonia.

Phosphatic Fertilizers. All phosphatic fertilizers are derived from mineral phosphates. Phosphate ore is mined, washed, and pulverized. It can then be applied directly as a fertilizer, or it can undergo further production to create other kinds of fertilizer.

Mixing-Only Fertilizers. The single-nutrient fertilizers produced by the processes described above are mixed to produce various combinations of mixing-only fertilizers. The resultant multinutrient fertilizers use phosphorus, nitrogen, or potash as active agents. These fertilizers are available in liquid, solid, or powdered form.

2.4.1.2 Major By-products and Co-products

The by-products of production (sulfur and ammonia) are captured to produce ammonium sulfate fertilizer. Dry blending produces a granulated product that is increasingly marketed on the global market. Another by-product is sulfuric acid (from phosphatic fertilizer production).

2.4.1.3 Types of Output

The main nitrogenous fertilizers in the United States are

- anhydrous ammonia,
- synthetic urea,
- aqua ammonia,
- ammonium nitrate,

- nitrogen solutions, and
- ammonium sulfate.

The main phosphatic fertilizers are

- direct application rock,
- normal superphosphate,
- wet-process phosphoric acid,
- triple (concentrated) superphosphate,
- diammonium phosphate,
- monoammonium phosphate,
- ammonium polyphosphate, and
- nitric phosphate.

Mixing-only fertilizers are available in any stable combination of the above in either granulated or fluid form.

2.4.1.4 Costs of Production

The most important input for nitrogenous fertilizer production is natural gas. Natural gas aids in the production of ammonia and is a preferred source of hydrogen for the fertilizer industry. The price of natural gas in the United States has increased significantly over the past decade, putting inflationary pressure on fertilizer prices. However, the cost of materials in general has only increased by 14 percent from 1987 to 1997. Labor inputs increased 78 percent from 1987 to 1994, but then dropped 31 percent by 1997. The overall increase in employment from 1987 to 1997 was 22 percent. Despite an overall increase in employment, payroll was actually 2.6 percent lower in 1997 than in 1987. Stricter environmental regulations have spurred an increase in research and development, which averaged $143.2 million a year over the 1987 to 1995 period.

In the phosphatic fertilizer industry, employment dropped 5.3 percent, but payroll rose by 11 percent between 1987 and 1997. Research and development expenditures followed the same trend as those for nitrogenous fertilizers.

The mixing-only fertilizer industry's costs and trends are affected by trends in the nitrogen and phosphatic fertilizer industries. A 16 percent increase in employment is matched by a 35 percent increase in payroll expenses between 1987 and 1997. Increased production was accompanied by increases in the cost of raw materials and vice versa. Because this industry mixes nitrogenous and phosphatic fertilizer products, their trends and costs have a direct impact on this industry.

2.4.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. The data indicate that plants manufacturing nitrogenous fertilizers (SIC 2873) and phosphatic fertilizers (SIC 2874) have been operating near full capacity, whereas plants manufacturing mixing-only fertilizers (SIC 2875) have been operating below capacity.

2.4.2 Demand Side of the Industry

2.4.2.1 Product Characteristics

Fertilizers deliver nutrients to soils that lack them, increasing the land's productivity. It is estimated that without fertilizers, the world would need to place 30 percent more land under cultivation to create an adequate food supply. Fertilizers are available in solid, granulated, and liquid form. Versatility of application is desirable because certain environments and soil types require liquids, while in other areas solids are better. Some fertilizers are combustible and therefore must be stored with care.

2.4.2.2 Uses and Consumers of Products

Fertilizers are used to increase crop yields per acre and restore nutrients to leeched soils. The principal consumers are individual farmers, agribusinesses, and government and quasi-government agencies. .

2.4.2.3 Substitution Possibilities

The principal substitutes for synthetic fertilizers are more traditional fertilizers--manure and compost. Although these natural fertilizers excel in many soil types, their quantity is not great enough to support modern agriculture.

2.4.3 Organization of the Industry

2.4.3.1 Firm Characteristics

Large corporations dominate the small ones in terms of output share in all three industries. The staying power of large companies is attributed to their ability to gather and spend resources on research and development in a political environment that favors increased environmental regulation (Sawinski, 1995).

The competitive nature of an industry can be broadly assessed by looking at the number of players in the industry. In 1992, 103 companies controlled 152 facilities in SIC 2875, 54 companies operated 75 facilities in SIC 2874, and 313 companies operated 401 facilities in SIC 2875. The large number of players in SIC 2875 indicates that it is a competitive industry.

Economists also estimate CR4 and CR8 and HHI to evaluate the competitiveness of a given industry. The four-firm concentration ratio for phosphatic fertilizers in 1992 was 62, meaning that the top four firms accounted for 62 percent of the industry's total sales. The phosphatic fertilizer industry is therefore considered to be less competitive, because a big share of the market is concentrated in the hands of a few large firms. On the other hand, the CR4 and CR8 for mixing-only fertilizers were 19 and 31 respectively, in 1992, indicating the presence of a competitive market. In 1992, the HHI for nitrogenous fertilizers was 792, so it is a less concentrated industry (i.e., more competitive). The HHI for phosphatic fertilizers was 1,528 (moderately competitive), and mixing-only fertilizers was 187 (more competitive).

Firms in these industries are either large public or private corporations or small private companies engaged in producing other chemicals in addition to fertilizers. Many of the other products produced by these companies are classified as industrial organic or inorganic chemicals.

2.4.4 Markets and Trends

Fertilizer production increased by 19.9 percent over the period 1989 to 1995.

Real growth in nitrogenous fertilizer production is not expected to exceed 1 or 2 percent a year in the future, partly because of the difficulty in handling gaseous anhydrous ammonia. Phosphatic fertilizers are predicted to follow a similar trend (Department of Justice and Federal Trade Commission, 1992).

The United States's decline in these industries relative to other countries is due to relatively less expensive natural gas in countries such as Russia, Canada, and Mexico for producing nitrogenous fertilizers. For phosphatic fertilizers, the emergence of Morocco as a significant producer will impact the United States's export markets. Morocco has four times the phosphatic ore deposits of the Unites States. The United States imported $1.4 billion worth of fertilizers in 1996, leaving net exports of $1.7 billion.

Domestic consumption of fertilizers is not expected to exceed the 1 to 2 percent growth in production in the foreseeable future.

The U.S. net exports of fertilizers in 1995 were valued at $1,831.6 million. The largest export markets are in South and East Asia. Foreign consumption of fertilizers produced by the United States has declined because of an oversupply caused by Morocco flooding the fertilizer market in attempts to gain foreign exchange.

2.5 Photographic Equipment and Supplies

All photographic chemicals, equipment, and supplies are classified under SIC 3861, photographic equipment. Establishments are divided into two groups, photographic apparatus and sensitized film and chemicals. Photographic apparatus include all cameras, both still and motion picture; tripods; editing equipment; photocopiers; and projectors. This industry profile focuses on photographic film, plates, and the chemicals used in the photographic process.

Shipments of photographic equipment declined 7.5 percent between 1987 and 1997. The overall photographic equipment industry (SIC 3861) grew through 1989. Subsequently, increased foreign competition and the early 1990s recession brought down the value of shipments. The industry went from a high of $24,919.4 million in 1989 to a low of $21,403.5 million in 1997. All values in this report are presented in 1998 dollars.[2]

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[2]Values adjusted using the plant cost index published in *Chemical Engineering*, various years.

The United States consumes 40 percent of the world's photographic chemicals and equipment, followed by Japan (27.8 percent), Western Europe (10.9 percent; excluding Germany), Germany (6.6 percent), Eastern Europe (10.3 percent), and Africa and Asia combined (2.8 percent) (see Figure 2-2).

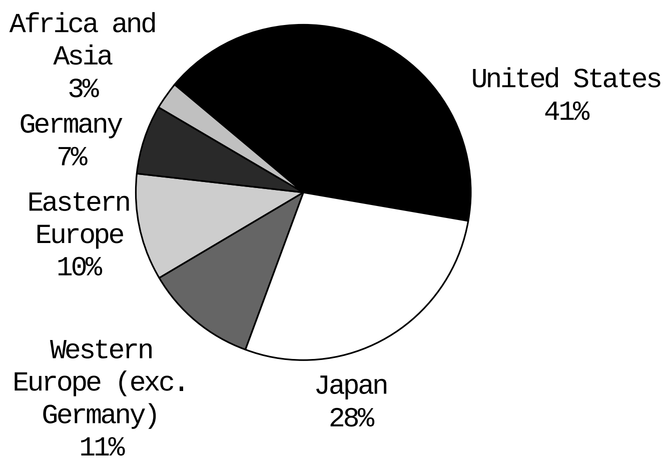

Figure 2-2. Worldwide Photographic Equipment and Supplies Consumption by Country

2.5.1 Supply Side of the Industry

Photographic materials are produced by coating film, plates, or paper with chemicals that hold latent images after exposure. The process begins with the growth of silver halide crystals, often in vessels as large as 2,000 liters in large commercial facilities. Silver ions from a silver nitrate solution and halide ions from alkali halide salt solution come together to form the silver halide. The crystals are suspended in a gelatin then washed to remove unwanted elements. Next, the silver halide is once again suspended in a gelatin, but it is cooled soon thereafter to form a gel. The silver halide is kept in gel form until further processing.

Once the manufacturer decides to take the process to the next step, the emulsion is melted and dyes may be added to increase sensitivity for one spectrum or another. After further sensitivization, the material is coated onto a support, usually paper, glass, film, or plates. Antifoggants, dye-release materials (for color film), and hardeners are added beforehand. Once the support is coated, the photographic materials are ready to be exposed.

The chemicals used to develop these photographic materials and toners are produced by mixing intermediate chemicals with necessary additives. The process depends on which of the over 60 chemicals is used in photographic materials development.

2.5.1.1 Major By-products and Co-products

The industry is inventing new techniques for reusing the film canisters and collecting and reusing the silver and gold used in production and from post-consumer products. The drying and disposal of photochemicals during the production and development of the product are on-going concerns.

2.5.1.2 Types of Output

SIC 3861 produces the following relevant products: sensitized blueprint cloth and paper; sensitized brownprint cloth and paper; sensitized diazo cloth and paper; sensitized motion-picture, x-ray, still camera, and special purpose films; sensitized graphic arts plates; heat sensitized paper made from purchased paper; sensitized latern slide plates; photographic metallic emulsion sensitized paper and cloth; packaged photographic chemicals; sensitized photographic paper and cloth; sensitized photographic plates; prepared and packaged photographic toners; and x-ray plates.

2.5.1.3 Costs of Production

The photographic equipment and supplies industry has invested heavily in new capital equipment to increase production efficiency. The early 1980s saw the industry employing over 100,000 employees. By 1997, that figure had dropped to 63,700. Most jobs lost have been at the production and distribution level. Total employment and payroll decreased approximately 28 and 15 percent, respectively. The cost of materials stayed fairly constant from 1987 to 1995 but rose to a new high of $8,143.0 million dollars in 1997. New capital investment averaged $924.0 million a year and energy costs averaged $203.3 million a year during this period.

2.5.1.4 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. The capacity utilization ratio for the photographic equipment and supplies industry was 83 percent in 1997.

2.5.2 Demand Side of the Industry

2.5.2.1 Product Characteristics

Photographic films, plates, and papers are available in different forms: disc format, cassettes, reels, 35 mm, 70 mm, and a variety of others. They can hold both color and black and white latent images.

Photochemicals and toners are used to develop the latent images captured by the photographic material and to enhance certain characteristics, such as color and texture.

2.5.2.2 Uses and Consumers of Products

The largest consumer group of photographic films is individual consumers. Photographic materials are used to capture images from holidays, ceremonies, vacations, religious days, national days, and other events deemed significant by the end user.

The motion picture and television industries of New York and California are the largest consumers of motion picture film. These films are used in the production of programs to be viewed in cinemas and on television.

Other significant user groups include photographers, hospitals (x-ray plates), commercial outfits, publishers, and all levels government agencies. Chemicals and toners are consumed predominantly by those who develop photographic materials.

2.5.2.3 Substitution Possibilities

For years, the only substitute for photographic products was videotape. However, many companies are currently developing products that capture images digitally. To date, digital products do not have the same quality and clarity as chemical products. But the medical industry is leading the push towards digital photography because of its advantages in storage, archiving, and electronic transport from one hospital to another.

2.5.3 Organization of the Industry

2.5.3.1 Firm Characteristics

Most firms in this industry are small and are involved in small-scale, specialized product production. Market-leaders are large, multinational firms that have just emerged from a period of corporate austerity and are streamlined and more efficient. In the early 1990s, many firms spun off subsidiaries and maneuvered themselves to become more vertically integrated (U.S. Department of Commerce, International Trade Administration, 1993). Eight hundred thirty-one companies controlled 904 facilities by 1992. In 1997, 694 firms controlled 738 facilities.

In both 1992 and 1997, firms with more than 100 employees dominated the market (in terms of value of shipments). This is not surprising because of the presence of the three largest companies in the photographic supplies and chemicals industry in America: Eastman Kodak, Polaroid, and DuPont. Establishments with more than 100 employees accounted for 86 percent of the industry's total value of shipments in 1992 and 90 percent of the industry's total value of shipments in 1997.

To assess the competitiveness of a market, economists often estimate CR4 and CR8 and HHI. The CR4 for photographic equipment in 1992 was 78, meaning that the top four firms accounted for 78 percent of the industry's total sales. The CR8 for the same year was 83 (U.S. Department of Commerce, 1995a). These high concentration ratios indicate that market share is concentrated in the hands of a few companies. Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. The HHI for photographic equipment was 2,408, more concentrated (i.e., less competitive) (U.S. Department of Commerce, 1995a).

2.5.4 Markets and Trends

2.5.4.1 Production

From 1987 to 1994, net imports of photographic equipment and supplies increased 27.6 percent. Imports supplied a greater fraction of the domestic market. Domestic production of these products decreased by 7.16 percent, outpacing the 3.8 percent decline in domestic consumption.

The United States is the largest producer of photographic chemicals and equipment in the world. Increasingly, Southeast Asia dominates still-camera hardware production. The United States has not, however, relinquished its control as the world market leader in photographic chemicals and films, plates, and papers production. Film, papers, and chemicals production is projected to increase an average of 2 percent a year through the end of the century.

Seventy-one percent of the United States' imports come from Asia, 62 percent of which are from Japan. Nearly all imports from Asia are produced by Japanese companies either in Japan proper or from overseas production facilities in Hong Kong, the Philippines, China, and ROC on Taiwan.

2.5.4.2 Consumption

Domestic consumption patterns are serviced by both American and foreign firms, mostly Japanese. In 1996, the U.S. trade deficit in this product category widened to $4,600 million, upon receipt of nearly $10,900 million in imports (all in actual dollars).

The largest foreign markets for U.S. photographic chemicals and films, paper, and plates are Europe, Asia, NAFTA members, and Latin America. In 1994, the United States exported $5,900 million worth of product.

2.6 Adhesives, Sealants, and Printing Ink

SIC 289 is reserved for industries that produce chemicals and allied products that are not classified in any of the other chemical subcategories (SIC 28). In 1995, adhesives and sealants (SIC 2891), printing ink (SIC 2893), and chemical preparations (SIC 2899) accounted for only 7 percent of the chemical industry shipments. Still they provide the U.S. economy with important products for automobiles and publishing houses, for instance. Shipments were valued at $25,382.2 million in 1997. All dollar values used in the subsequent analysis are 1998 dollars unless otherwise noted.[3]

The adhesives and sealants industry (SIC 2891, NAICS 325520) comprises establishments engaged in manufacturing adhesives for industrial and manufacturing uses. The industry has

[3]Values adjusted using the plant cost index published in *Chemical Engineering*, various years.

experienced an increase of 31 percent in the value of shipments from 1987 to 1997. Most of the increase is due to a sharp 12 percent rise in shipments between 1996 and 1997.

The printing ink industry (SIC 2893, NAICS 325910) comprises establishments engaged in manufacturing printing inks such as gravure ink, screen process ink, and lithographic ink. The value of industry shipments grew 45 percent between 1987 and 1997, despite the recession of the early 1990s. In 1997, the industry's shipments were valued at $4172.4 million.

The chemical preparations industry (SIC 2899) shipped $13,821.9 million worth of product, more product(in terms of dollar value) than the adhesives and sealants and printing ink industries combined. This industry is diverse, with a wide range of products, including bluing, writing ink, industrial compounds, and fatty acids.

2.6.1 Supply Side of the Industry

2.6.1.1 Production Processes

Adhesives and Sealants. The manufacturing process for adhesives and sealants involves combining raw materials in the production apparatus. After the mixing and heating processes have been completed, the mixture is prepared for packaging. Colorants and other additives are added to the mixture during the later stages of production.

Printing Ink. To manufacture ink, the producer subjects dry components to two general processes: mixing and milling. Mixing involves wetting the dry pigments and additives with a liquid vehicle (resins and solvents), until there is no discernible dry pigment remaining. Ideally, a finished ink is produced during this stage or after subsequent dilution. Milling can be used to break components down further to create a finer solution, if desired. The most important aspect of ink manufacture is the proper dispersion of pigments in the vehicle. For liquid inks, the paste is placed into a dissolver and more resins and solvents are added to create an ink with the desired consistency.

2.6.1.2 Major By-products and Co-products

There are no significant by- or co-products generated during the manufacture of adhesives and sealants or printing ink.

2.6.1.3 Types of Output

The adhesives and sealants industry produces the following products: adhesives, caulking compounds, both linoleum and mending cements, epoxy adhesives, all glues (except dental), household iron cement, joint compounds, laminating compounds, mucilage, adhesive paste, household porcelain cement, sealing compounds for pipe threads and joints as well as for synthetic rubber and plastics, and sealing wax.

The printing ink industry produces lithographic inks, screen process ink, bronze ink, flexographic ink, gold ink, duplicating ink, letterpress ink, offset ink, base and finished printing ink, and gravure ink. Writing and drawing inks are not included in this classification.

2.6.1.4 Costs of Production

The adhesives and sealants industry was seemingly stagnant over the period 1987 to 1992. However, growth in the industry has since been spurred by product innovations and new applications or the adaptation of adhesives and sealants to existing manufacturing technologies. Investment in research and development and falling labor costs due to increased mechanization have allowed the industry to become more efficient. Most of the 3,600 jobs eliminated from the industry from 1987 to 1996 have been at the production level. There was substantial growth in the industry between 1996 and 1997, which was accompanied by a 20 percent increase in employment (20 percent) between 1996 and 1997. Over 1987 to 1997, the cost of materials fell by 18 percent.

Adhesives and sealants manufacturers are counting on proactive research and development to keep them one step ahead of environmental regulators and market demands. In particular, the Clean Air Act motivates them to develop new products (Tollefson, 1994).

Unlike the adhesives and sealants industry, the printing ink industry’s growth has been matched by an equivalent growth in input costs. From 1987 to 1997, the printing industry’s value of shipments increased 45 percent in real terms. Accompanying this increase, payroll costs have risen by 36 percent, materials by 48 percent, and energy by 16 percent. The industry anticipated the rising costs of raw materials and labor. However, environmental initiatives are a growing concern, specifically those pertaining to air permit compliance for volatile organic compounds (VOCs) and hazardous air pollutants (HAPs).

2.6.1.5 Capacity Utilization

Capacity utilization for the industry has generally fallen between 70 and 80 percent between 1992 and 1997. From 1993 to 1998, the capacity utilization rates for adhesives and sealants (SIC 2891), printing ink (SIC 2893), and chemical preparations (SIC 2899) fell on average from 81 percent to 68.3 percent (U.S. Department of Commerce, 2000).

2.6.2 Demand Side of the Industry

2.6.2.1 Product Characteristics

Adhesives and sealants are as varied as printing inks in terms of viscosity and physical characteristics. Those differences aside, all adhesives help to distribute pressure and stress over a wide area and resist vibration, in addition to joining two surfaces. Sealants prevent the passage of air, water, or chemicals between two surfaces. Sealants, however, do not have the same cohesive power as adhesives.

The adhesives and sealants industry is in a state of transition; products are being reformulated to better serve consumers and adjust to current and pending environmental regulations.

Printing inks are available in two forms, pastes and liquids. Although all inks share the ability to be applied to a variety of surfaces, inks differ in their viscosity, composition, method of drying, and physical appearance. These differences are largely the result of differing applications and uses. However, they all color a surface to produce a desired effect. In the 1990s, inks became increasingly water-based, a shift away from the traditional resins and solvent-based inks.

2.6.2.2 Uses and Consumers of Products

Adhesives and sealants are used by individual consumers and the construction, packaging, furniture, appliance, textile, aircraft, and other industries. Technological advances have contributed to their use by the automotive industry to help build lighter and more fuel-efficient cars. Adhesives have replaced metal fasteners and spot welds because adhesives do not suffer from the same traditional bonding corrosion that metals often do. Automotive applications of adhesives have experienced the largest growth rates.

Printing inks are used by publishing, printing, and copy houses and are the most essential input in that process. Writing and drawing inks are not included in this SIC code. Common consumers include publishers, newspapers, copy centers, and the technology industry.

2.6.2.3 Substitution Possibilities

Substitutes for adhesives and sealants vary depending on their use. For instance, in the automotive industry, two steel surfaces can be welded together rather than attached using an adhesive. Currently, there are no substitutes for printing inks. However, within the industry, powders, pastes, and liquids are interchangeable, depending on the nature of their application.

2.6.3 Organization of the Industry

2.6.3.1 Firm Characteristics

The number of companies in the adhesives and sealants industry (SIC 2891) decreased from 537 to 517 over the 1987 to 1992 period (U.S. Department of Commerce, 1995e; U.S. Department of Commerce, 1990d). The number of facilities in this industry also decreased from 714 to 685 during the same period.

The number of companies in the printing ink industry (SIC 2893) decreased from 224 to 220, while the number of facilities increased from 504 to 519 between 1987 and 1992. The printing ink industry is dominated by medium-sized firms. Firms with between 20 and 250 employees accounted for 71.25 percent of all shipments in 1987. This percentage increased to 77.2 percent in 1992. However, most facilities have fewer than 50 employees.

Most facilities are located in states with significant publishing and printing sectors for printing ink and near key durable goods production centers for adhesives and sealants.

Measures of market concentration are often used as empirical guides to assess the competitiveness of a market. Typical measures include CR4 and CR8 and HHI. According to all these measures, the industry is relatively unconcentrated.

2.6.4 Markets and Trends

In the adhesives and sealants industry, production (as measured by value of shipments) declined by 0.5 percent, while consumption fell by 2.8 percent during the period 1987 to 1994.

There was an accompanying increase (445.9 percent) in net exports of adhesives and sealants during the same period.

Reliable net export statistics are unavailable for the printing ink industry for the period prior to 1990. Data for subsequent periods indicate the increase in foreign competition faced by the printing ink industry. Domestic production grew by 17.3 percent and consumption grew by 20.9 percent between 1990 and 1995. Domestic printing ink demand was increasingly supplied by foreign producers, especially those from East Asia. The United States moved from being a net exporter in 1990 to a net importer by 1995, because of a major import surge.

2.6.4.1 Production

In 1997 the adhesives and sealants industry was valued at $25 billion (1997 dollars) and is expected to grow at 3.0 percent for the next few years. But growth as high as 10 percent is expected by *Chemical Marketing Reporter Magazine* for some niche markets (Tollefson, 1994).

The printing ink industry is not anticipating any further growth until publishing houses recover from the recessionary effects of the 1995 paper price increases.

Adhesives and sealants imports were valued at $112.0 million in 1996 (actual dollars). Most of these imports came from the European Union and NAFTA countries.

In 1996, the United States imported $272.7 million (actual dollars) worth of printing inks, the bulk of which came from Asia and Europe (DRI McGraw Hill, 1998).

2.6.4.2 Consumption

Domestic adhesives and sealants' demand is projected to match production and imports. Certain sectors, like the automotive and dental industries, will demand a larger quantity than they currently do. U.S. consumption of printing inks is not expected to increase in the coming years (DRI McGraw Hill, 1998).

Total global demand for adhesives and sealants was estimated to reach 1.3 million tons annually by the year 2000 (DRI McGraw Hill, 1998). In 1996, the domestic adhesives and sealants industry exported $202 million (actual dollars) worth of products to the rest of the world. Canada and Mexico remain the largest export markets.

In 1996, the United States exported $212.8 million (actual dollars) worth of printing ink products. The fastest growing international market for this industry is Asia (DRI McGraw Hill, 1998).

2.7 Man-Made Fibers, Noncellulosic

The synthetic materials industry in the United States accounts for nearly 25 percent of the $300 billion a year chemical industry; while man-made fibers contributed 6.25 percent to that total. SIC 2824 (NAICS code 325222), Organic Fibers (Noncellulosic), comprises 90 percent of total man-made fiber production. Organic fibers are used in products as varied as clothing and tires (Mote, 1994). These fibers are largely intermediate goods and are shipped to other manufacturers in the form of yarn, tow, staple, or monofilament. Thereafter, they are transformed into consumer and industrial products. In addition to being less expensive than natural fibers, synthetic fibers are also more durable, hold their shape better, and are more uniform.

The non-cellulosic, man-made organic fibers industry has experienced a mild roller coaster effect on its revenues in the last year. During the late 1980s, the synthetic fiber industry experienced steady growth. Between 1987 and 1989 the value of shipments grew 6.3 percent. However, that growth was negated during the recession in 1991 and 1992. The industry began recovering in 1993, and value of shipments rose by approximately 10.3 percent between 1991 and 1996, only to fall again in the following 2 years to reach $12,004.8 million in 1997. All dollar values cited in this report are in constant 1998 dollars, unless otherwise indicated.[4]

2.7.1 Supply Side of the Industry

2.7.1.1 Production Processes

Man-made synthetic fibers are derived from both natural and petroleum-based ingredients that are melted together to form liquids containing free-moving molecules. The liquid passes through small holes in vats called spinnerets. As the liquid exits the vats, it hardens to form long filaments.

In all these processes, as the fiber is being spun it is manipulated to adopt various physical properties, such as drapability, softness, elasticity, stiffness, roughness, and resilience. After the

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[4]All values inflated using the plant cost index published in *Chemical Engineering*, various years.

spinning process, the fibers are stretched and oriented in preparation for dyeing, water resistance, stretch ability, and strength treatment. The product is then prepared for packaging and shipping.

2.7.1.2 Major By-products and Co-products

SIC 2824 has no co-products. Few by-products are associated with man-made fibers. Emissions from man-made fiber production are largely recovered by using activated carbon. However, no stringent air pollution controls are used, meaning that some carbon disulfide and hydrogen sulfide escape during production.

2.7.1.3 Types of Output

The man-made fiber industry produces fibers derived from molecules containing combinations of carbon, hydrogen, nitrogen, and oxygen. The output includes polyester, nylon, olefins, and acrylics.

These fibers are sold to manufacturers in four forms: yarn, monofilament, staple, and tow. Monofilaments are single, long strands used in toothbrushes and nylon stockings. Staple comprises fibers that are cut short. Staple is usually blended with other materials to form yarns. Tow is much like staple, but it is kept in long, rope-like form before being cut at a later time.

2.7.1.4 Costs of Production

New capital investments, increased productivity, and technology improvements have allowed the industry to cut its labor costs (Mote, 1994). The number of people employed by the man-made fiber industry has been reduced drastically over the past 15 years. In 1982, SIC 2824 employed over 60,000 people. By 1990, employment had dropped to 48,100. Since 1990, employment has further decreased by 11,000 jobs (23 percent) to level out at 37,100 jobs in 1997. Job-loss was concentrated in two areas: production-level positions and middle management. Increased automation, foreign competition, and new information technologies replaced human labor in these two areas. Over the period 1987 to 1997, the industry reduced its payroll 9.8 percent, from $1,602.0 million to $1,445.3 million. By comparison, the costs of materials fell by only 6.5 percent during the same period. The drop in costs is most likely because of the decline in the level of production. New capital investments averaged $762.8 million a year from 1987 to 1995. Investments contributed to the creation of new production strategies to help minimize increasing costs and make the production process more efficient (Mote, 1994). Energy costs averaged $455.8 million during the 1987 to 1997 period.

2.7.1.5 Capacity Utilization

utilization for the man-made fibers industry. The full production capacity utilization ratio for the noncellulosic man-made fibers industry was 92 in 1997. Thus, plants manufacturing these fibers (SIC 2824) have been operating near full capacity.

2.7.2 Demand Side of the Industry

2.7.2.1 Product Characteristics

Man-made fibers are valued for their versatility and variety. They are less expensive than most natural fibers and are more durable and uniform. Used predominantly by the apparel and textile industry, synthetic fibers are flexible and resist aging and do not react to exposure to the elements. The fibers can be manipulated during the manufacturing process to become softer, rougher, stronger, or more resilient. They can be dyed and are easily woven to form other materials. Polyester and nylon are two key fibers produced by this industry. Polyester does not retain moisture, provides excellent electrical insulation, and is highly resistant to solvents. Nylon has a high strength-to-weight ratio, is not easily permanently deformed, and is resistant to abrasion.

2.7.2.2 Uses and Consumers of Products

The largest consumer of synthetic fibers is the floor-coverings industry. This sector consumes roughly 32 percent of all fibers produced to make floor coverings for residential, institutional, and industrial purposes. The apparel and various household textile industries consume about 25 percent and 10 percent respectively. The remainder is used in such varied industries as tires (for reinforcement), rope, surgical and sanitary supplies, fiberfill, electrical insulation, and plastics reinforcements.

Polyester fibers are used predominantly by the home furnishings and apparel industries, as well as general textile facilities. Nylon is mostly used in carpeting, but also in apparel, noncarpet home furnishings, ropes, and miscellaneous industrial products. Acrylics and olefins are used in apparel and highly durable carpeting, respectively. In response to increasing pressure from both the government and environmental groups, the industry is seeking methods for recycling fibers such as polyester into new fabrics and carpet materials.

2.7.2.3 Substitution Possibilities

Synthetic fibers were originally invented to provide the strength and durability that was lacking in natural fibers such as cotton and wool. Man-made fibers are also less expensive to produce. Natural fibers may be substituted for man-made ones in apparel, but these fibers do not have the same resistance to wear and tear that is necessary for use in tires, carpeting, meshes, and other products. Within the industry, polyester, acrylic, olefin, and nylon fibers have their own market segments. There is very little substitution between fibers because each fiber is valued for its unique properties. However, substitutions can occur between varying levels of quality and producers within each market segment.

2.7.3 Organization of the Industry

2.7.3.1 Firm Characteristics

Traditionally, the nature of the technology and capital costs associated with the manufacture of noncellulosic organic fibers permitted few firms to break into the market. However, between 1992 and 1997, some of those barriers broke down and the number of facilities in the industry increased.

Market structure can affect the size and distribution of regulatory impacts; therefore, we examine the structure of the man-made fiber industry next. The highly concentrated nature of the man-made noncellulosic fibers industry is also indicated by its HHI of 2,158, and by the fact that the largest 8 companies account for 90 percent of the value of shipments.

2.7.4 Markets and Trends

2.7.4.1 Production

Between 1987 and 1994, production slowed by 3.9 percent in terms of value of shipments, accompanying a 0.5 percent drop in consumption and a 61.9 percent drop in net exports. Domestic output fell by 3.9 percent between 1987 and 1994 in the face of competition from producers in emerging markets such as Asia and Latin America. However, U.S. corporations still control about 90 percent of the domestic market despite foreign competition.

U.S. corporations controlled roughly 18 percent of the global market for man-made fibers in 1992. That figure was as high as 50 percent in 1950. In 1992, the United States imported nearly

$900 million worth of man-made fibers. Fifty percent of the present worldwide capacity for polyester production is in Asia, compared to 13 percent in the United States.

2.7.4.2 Consumption

The U.S. Department of Commerce expects the man-made fiber market to grow by 19 percent between 1995 and 2000. Consumption of polyester, the most popular fiber, is expected to increase 16 percent over the same period.

The United States is the world's largest exporter of synthetic fibers, followed by Taiwan and Japan. Other significant exporters are Austria, Canada, and the Southeast Asian nations. The United States exported $1.7 billion (in nominal terms) in 1992, but producers from emerging countries such as Indonesia and China are increasing their share of the global market.

2.8 Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers

The Plastic Materials, Synthetic Resins, and Nonvulcanizable Elastomers industry is a relatively small organic chemical sector. In 1997, the sector (SIC 2821, NAICS 325211) shipped $49,282 million dollars worth of products. All dollar values are 1998 dollars unless otherwise indicated. This industry supplies essential products to major manufacturing and consumer industries from automobiles to home furnishings. Table 2-2 shows value of shipments for SIC 2821. Over the period 1987 to 1997, shipments grew at an average rate of 8 percent per year.

Typical products manufactured by the industry include cellulose plastics materials, phenolic and other tar acid resins, urea and melamine resins, vinyl resins, styrene resins, alkyd resins, acrylic resins, poolyethylene resins, polypropylene resins, rosin modified resins, and other miscellaneous resins. SIC 2821 produces resins that are inputs into the production of fabricated plastics products or plastics film, sheet, rod, and other products. Production of fabricated plastic products and compounding of resins are classified as separate industries.

Plastic materials were first developed in the mid-1800s, with new resins being developed at an accelerated pace during the first half of the twentieth century. Most of the primary thermoplastic resins currently in use were developed during the period between 1900 and 1940**.** The advent of World War II brought plastics into great demand as substitutes for other materials that were in short supply, such as natural rubber.. During the decades following World War II, additional new resins were developed, and the introduction of alloys and blends of various polymers made it possible to

Table 2-2. Value (1998 $$10^6$) of Shipments

Year	SIC 2821
1987	$22,173
1988	$33,217
1989	$35,192
1990	$31,393
1991	$29,290
1992	$29,640
1993	$29,982
1994	$36,566
1995	$49,634
1996	$43,093
1997	$49,282

Prices adjusted using the PPI for SIC 2821.

Sources: U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Paints and Allied Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. August 1997b. *1996 Current Industrial Reports: Paint, Varnish, and Lacquer*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999h. *1997 Economic Census*. Washington, DC: Government Printing Office.

U.S. Bureau of Labor Statistics, Producer Price Index Revision—Current Series. Series ID PCU2821#. <http://www.bls.gov>. Obtained August 18, 2000

tailor properties to fit specific performance requirements. The demand for plastics increased steadily, as designers and engineers began to substitute plastics for other more traditional materials in production of automobiles, producer goods, and consumer goods (SPI History, 2000).

2.8.1 Supply of Plastic Materials and Resins

2.8.1.1 Production Processes

Polymers and resins are generally produced through a polymerizing chemical reaction, with the specific chemical reagents depending on the specific resin to be produced. Acetal resins are produced by the polymerization of purified formaldehyde into both homo polymer and copolymer types. Amino resins include both melamine and urea resins. Melamine resins are formed by the condensation reaction of formaldehyde and melamine. Urea resins are formed by the condensation reaction of formaldehyde and urea. Phenolic resins were the first commercialized wholly synthetic polymer of plastic. The basic raw materials are formaldehyde and phenol.

2.8.1.2 Types of Output

Plastic resins can be divided, generally, into thermoset resins, which first liquify then harden in the presence of heat, and thermoplastic resins, which become pliable in the presence of heat. Thermosets include epoxy, polyester (unsaturated), urea and melamine, and phenolic resins. Thermoplastics include low density polyethylene, high density polyethylene, polypropylene, acrylonitrile-butadiene -styrene (ABS), Styrene-Acrylonitrile (SAN), polystyrene, nylon, polyvinyl chloride, thermoplastic polyester, and engineering resins. In 1997, total value of shipments for the industry (in 1998 dollars) was $49,282 million. Of that total, approximately $40,615 million (82 percent) were shipments of thermoplastic resins, and $8,229 million (18 percent) were shipments of thermosetting resins.

2.8.1.3 Costs of Production

The inputs for plastic materials and resins include raw materials, especially petrochemicals. Other inputs include labor and energy. In constant 1998 dollars, the cost of materials more than doubled over the period 1987 to 1997, as output also more than doubled (see Table 2-3).

2.8.1.4 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio measures the ratio of actual operations to the full capacity production levels. Capacity utilization ranged between 84 percent and 89 percent over the period 1993 to 1998.

Table 2-3. Inputs Used in Plastic Materials and Resins Industry

Year	Labor: Quantity (10^3)	Labor: Payroll (1998 $$10^6$)	Materials (1998 $$10^6$)	New Capital Investment (1998 $$10^6$)	Energy (1998 $$10^6$)
1987	56.3	1,695	13,019	1,054	NA
1988	58.3	2,245	20,001	1,661	NA
1989	62	2,522	21,474	2,081	NA
1990	62.4	2,491	19,433	2,442	NA
1991	60.5	2,457	18,420	2,231	NA
1992	60.4	2,530	17,838	1,617	1,067
1993	62.2	2,661	18,534	1,830	1,177
1994	69.2	3,116	21,701	2,527	1,267
1995	70	3,783	29,967	2,654	1,408
1996	58.6	3,078	26,684	2,992	1,482
1997	61.035	3,465	28,090	NA	1,690

Prices adjusted using the PPI for SIC 2821.

2.8.2 Demand for Plastic Materials and Resins

Individual plastic materials and resins are valued because they have specific product characteristics that make them well suited for particular uses. Typically, plastic materials may be lighter, stronger, and/or more durable than some other traditional materials.

2.8.2.1 Uses and Consumers of Plastics

Plastic resins are processed by plastic fabricators into plastic materials, which them may be further processed prior to incorporation into final products. Major markets for plastic materials and resins include transportation, packaging, building and construction, electrical/electronics, furniture and finishings, consumer and institutional users, Industrial/machinery, adhesives/inks/coatings. Table 2-4 shows total resin use by major market over the period 1992 to 1996. Overall, plastic sales and use grew by an average of five percent per year over the period, with even faster growth occurring in the transportation, building and construction, furniture and furnishings, and industrial/machinery markets.

Table 2-4. Total Resin Sales and Captive Use by Major Market (millions of pounds, dry weight basis)

Major Market	Year 1992	1993	1994	1995	1996	Growth Rates (%)
Transportation	2,817	3,221	3,795	3,916	3,964	6.8
Packaging	18,284	19,569	19,551	19,334	21,271	3.0
Building and Construction	11,876	12,885	14,715	14,321	16,199	6.2
Electrical/electronic	2,766	2,981	3,325	2,966	3,137	2.5
Furniture and Furnishings	2,559	2,759	3,118	3,198	3,477	6.1
Consumer and Institutional Uses	6,093	6,015	9,266	9,054	9,804	9.5
Industrial/machinery	671	768	836	818	980	7.6
Adhesives/Inks/Coatings	1,723	1,572	1,789	1,795	1,833	1.2
All Other	6,877	7,234	7,515	8,050	9,361	6.1
Exports	6,950	6,632	6,889	7,742	8,722	4.5
Total	60,562	63,636	70,799	71,194	78,748	5.3

Prices adjusted using the PPI for SIC 2821.
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2.8.2.2 Substitution Possibilities

Substitutes for plastics include all traditional materials. Substitutes for specific resins include other resins as well as traditional materials. Because plastics are formulated and compounded to have specific properties demanded for particular uses, other materials are imperfect substitutes for specific resins. Holding other things equal, this would tend to make demand for specific plastic resins somewhat inelastic.

2.8.3 Organization of the Industry

2.8.3.1 Firm Characteristics

As shown in Table 2-5, in 1997 and in 1992, the largest number of plastics establishments had between 20 and 49 employees. However, the largest share of the industry's value of shipments was produced by establishments with between 100 and 249 employees. More than 75 percent of the value of shipments is produced by establishments having more than 100 employees. This suggests that the industry is somewhat dominated by large plants.

Table 2-5. Size of Establishments and Value of Shipments for SIC 2821, 1997

	1992		1997	
Employment Size Category	**Number of Establishments**	**Value of Shipments by Employment Size (1998 $\$10^6$)**	**Number of Establishments**	**Value of Shipments by Employment Size (1998 $\$10^6$)**
1 to 4 employees	26	27.26897	21	13.59
5 to 9 employees	36	86.44641	38	186.32
10 to 19 employees	47	266.0618	56	539.03
20 to 49 employees	110	1,376.325	160	3,417.65
50 to 99 employees	101	3,888.289	114	5,958.24
100 to 249 employees	72	6,627.684	94	13,837.61
250 to 499 employees	30	5,150.71	28	8,971.34
500 to 1,000 employees	19	6,657.131	14	7,968.88
over 1,000 employees	8	a	7	a
Total	449	29,639.76	532	49,282.185

Prices adjusted using the PPI for SIC 2821.

[a] Not shown to avoid revealing company-specific data. Data are included in totals.

The four- and eight-firm concentration ratios (CR4 and CR8) and HHI are used to assess the market structure of an industry. The CR4 for the plastic materials and resins industry was 24 in 1992, meaning that the top four firms accounted for only 24 percent of the industry's total sales. The CR8 for the same year was 39 (U.S. Department of Justice, 1992). This indicates that the plastic materials and resins market is fairly competitive. Furthermore, the HHI for the plastic materials and resins industry was 284 in 1992. According to the Department of Justice's (1992) Horizontal Merger Guidelines, industries with HHIs below 1,000 are considered to be unconcentrated (i.e., more competitive). Therefore, firms in the plastics and resins industry are more likely to be price takers. Table 2-6 shows the CR4, CR8, HHI, number of companies, and number of facilities data for SIC 2821 for 1992.

Table 2-6. Measures of Market Concentration by SIC: 1992

SIC	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2821	Plastic materials and resins	24	39	284	241	449

Source: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

2.8.3.2 Geographical Distribution

Texas dominates the production of plastic materials and resins. As shown in Table 2-7, Texas has more than twice as many facilities, twice as much output, and twice as many employees in the industry as the next largest states. With 68 plants, Texas has more than 12 percent of the total 532 plastic materials facilities in the country. Other states with a large number of facilities or a large value of shipments include two of Texas' neighbors, Oklahoma and Louisiana, as well as Kentucky and Indiana.

2.8.4 Markets and Trends

Table 2-8 shows production and consumption trends for the period 1992 to 1997. There has been considerable growth in the production and consumption of plastics during the period. From 1992 to 1997, both production and consumption grew at an average rate exceeding 9 percent per year. Exports and imports both more than doubled during the period, with net exports being positive and growing, so that domestic production exceeded domestic consumption by a growing margin.

2.8.4.1 Production

Domestic. Domestic production grew from $31.5 billion to $50.5 billion during the 5 years from 1992 to 1997. Production grew at an annual rate of more than 9 percent over the 5-year period, with a 1-year downturn in 1996.

Table 2-7. Industry Statistics for the Top Ten States for SIC 2821, 1997

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees	Number of Employees
Texas	$16,050.4	68	53	12,920
Louisiana	$6,617.3	21	19	5,152
Kentucky	$2,822.0	14	13	2,986
Oklahoma	$1,834.5	34	29	3,088
Indiana	$1,656.7	15	13	2,711

Prices adjusted using the PPI for SIC 2821.

Source: U.S. Department of Commerce, Bureau of the Census. 1999h. *1997 Economic Census*. Washington, DC: Government Printing Office.

Table 2-8. Production and Consumption Trends for SIC 2821, 1992 to 1997 (1998 $\$10^6$)

Year	Domestic Production	Value of Imports	Value of Exports	Apparent Consumption
1992	31,529	2,033	6,714	26,848
1993	31,924	2,477	6,919	27,482
1994	37,633	3,344	8,437	32,540
1995	50,278	4,797	11,949	43,126
1996	45,945	4,633	11,505	39,073
1997	50,493	5,294	13,139	42,648

Prices adjusted using the PPI for SIC 2821.

Foreign. Foreign plastic materials producers increased their sales to the United States during the period. In 1997, U.S. imports were $5.2 billion.

2.8.4.2 Consumption

Domestic. Domestic consumption grew at an annual rate of more than 9 percent over the period from 1992 to 1997, with a 1-year downturn in 1996.

Foreign. In 1997, U.S. plastic materials producers exported $13.1 billion of plastic resins to NAFTA countries, western Europe, and Asia.

2.8.4.3 Trends

For the near term, 2000-2004, the outlook for plastics will continue to be favorable, with constant dollar shipments growing between 3 and 4 percent per year. A somewhat weaker domestic economy is projected to reduce consumption in some key end-use markets, including construction and transportation. However, economic recoveries in Asia and Latin America are projected to somewhat offset the slowing domestic demand (McGraw-Hill, U.S. Department of Commerce, 2000).

2.9 Industry Organization

This section provides information for describing firm behavior within markets for miscellaneous organic chemicals, describes the location of facilities producing miscellaneous organic chemicals within each market segment, and characterizes the companies owning miscellaneous organic chemicals plants.

Market structure is of interest because it determines the behavior of producers and consumers in the industry. If an industry is perfectly competitive, then individual producers are unable to influence the price of the output they sell or the inputs they purchase. Competitive conditions are most likely in industries with a large number of firms, homogeneous inputs and outputs, and few barriers to entry or exit. Of the industries profiled above, the vast majority are considered not concentrated according to concentration ratios and the HHI. Inputs and outputs are typically industrial organic chemicals or coatings, which are fairly homogeneous. Thus, we are modeling the industry as perfectly competitive.

2.9.1 Production Facilities

EPA estimates that 370 facilities produce MON products, including 207 that produce MON chemicals using batch processes, 140 that produce MON chemicals using continuous processes, and 127 that produce MON coatings. Of the 368 facilities, 64 use both batch and continuous processes to produce organic chemicals; 15 produce both coatings and continuous-process MON chemicals; 12 produce both coatings and batch-process organic chemicals; and two produce coatings, batch-process chemicals, and continuous-process chemicals.

MON facilities are located in 35 states, with the largest number of facilities concentrated in Texas, Illinois, Louisiana, and Ohio. Table 2-9 shows the geographic distribution of MON facilities.

Table 2-9. Number of MON Facilities by State

State	Number of Facilities	State	Number of Facilities
AL	8	NC	14
AR	5	NJ	17
CA	20	NV	1
CT	3	NY	12
DE	2	OH	26
FL	6	OK	2
GA	7	OR	2
IA	4	PA	18
IL	52	RI	1
IN	8	SC	6
KS	4	TN	10
KY	4	TX	57
LA	27	VA	6
MA	1	WA	1
MD	6	WI	4
MI	9	WV	6
MN	2	None	4
MO	13		
MS	2	Total	370

Many of the MON facilities are characterized by SIC codes that indicate the primary industrial activity at that site. Table 2-10 shows SIC codes for facilities in each industry segment.

Table 2-10. Number of Facilities by SIC Code by Industry Segment

SIC Code	Paints and Coatings	Batch Organic Chemicals	Continuous Organic Chemicals
2812			2
2813			2
2819		1	3
2821	3	40	26
2822			3
2823		1	
2824		1	
2833		1	1
2841		2	
2843		6	2
2851	96	14	36
2861		4	1
2865		16	4
2869		56	38
2873			7
2879		1	2
2891	13	2	4
2893	14		2
2899		15	5
2911			1
3081			1
None	1	47	
Total	127	207	140

2.9.2 Quantities of MON Commodities Produced

EPA has data on quantities of MON coatings produced and quantities of MON organic chemicals produced using the batch process for many affected facilities. Because many of these data have been claimed by the companies as confidential business information (CBI), and because the product descriptions given by the companies were company-specific and difficult to interpret, EPA has for modeling purposes aggregated across all products within each of these two sectors to estimate the total market quantity of MON organic chemicals and MON coatings. EPA estimates that production of MON coatings totals 1,190,674 metric tons and that production of MON organic chemicals using batch production processes totals 4,351,289 metric tons (refer to Section 4 for further analysis). EPA does not have data on the quantity of MON organic chemicals produced using continuous production processes. To model the impacts of the proposed rule on the market for MON organic chemicals, EPA assumed that the quantity produced using continuous processes is equal to the quantity produced using batch processes. EPA therefore estimates that the total quantity of MON organic chemicals produced is 19,186,000,000 pounds. Because of the uncertainty about the quantity of chemicals produced using continuous processes, EPA performed a sensitivity analysis, assuming that continuous MON chemical production is half that of batch processes (14,390,000,000 pounds) and also that it is 1.5 times that of batch processes (23,983,000,000 pounds).

SECTION 3

ENGINEERING COST AND EMISSION REDUCTION ESTIMATES

This section presents the Agency's estimates of the compliance costs associated with the proposed NESHAP on the production of miscellaneous organic chemicals, including coatings and other organic chemicals. This regulation will affect all 127 facilities producing paints and allied products and all 107 facilities producing batch chemicals. The Agency estimated facility-specific costs for these two industry segments. The Agency is not certain how many of the 127 facilities producing organic chemicals using continuous processes will incur costs. The Agency has estimated the total costs for this industry segment but was not able to assign costs to individual facilities.

3.1 Control Costs

Estimated costs of control include the following types of costs:

- total capital costs, an estimate of the cost of investment in new plant and equipment required to comply with the proposed regulation;
- operating and maintenance costs, which include the annual costs of compliance such as additional labor, materials, or energy used for compliance activities, monitoring, recordkeeping, and reporting;
- product recovery credits; and
- total annual costs, which include annual capital costs, annual operating and maintenance costs, and recovery credits.

3.2 National Emissions Reductions and Compliance Costs

EPA's estimated costs of control are shown in Table 3-1, along with baseline emissions and estimated emission reductions. For each market segment, the proposed MACT standard would result in substantial reductions in HAP emissions. The emission reductions range from approximately 38 percent for continuous process organic chemical producers to nearly 73 percent

Table 3-1. Estimated Baseline HAP Emissions, Emission Reductions, and Cost of Compliance for Facilities Affected by the MON

	Baseline HAP Emissions (tn/yr)	HAP Reduction (tn/yr)	Total Annual Cost ($/yr)	Total Capital Cost ($/yr)	Operating & Maintenance ($)	Annualized Capital Costs ($/yr)	Recovery Credit ($)	Cost-effectiveness ($/tn HAP)
Costs for Batch Chemical Producers								
Minimum	—	—	—	–1,697	—	–186	—	
Mean	237.3	110.0	270,194	413,657	234,247	45,420	9,469	
Maximum	2,557.5	1,667.1	3,579,843	3,042,470	3,254,441	334,064	150,788	
Total, Batch Facilities	49,120.8	22,774.7	55,930,257	85,626,995	48,489,182	9,401,865	1,960,135	2,447
Total, Continuous Facilities	13,805.3	5,234.5	22,288,551	33,244,471	19,577,187	3,650,272	938,233	4,255
Total, Organic Chemical Producers	62,926.1	28,009.2	78,218,808	118,871,466	68,066,369	13,052,137	2,898,368	2,800
Costs for Coating Producers								
Minimum	1.7	0.4	6,048	5,148	5,394	733	79	
Mean	61.4	44.7	126,092	452,893	85,909	49,990	9,808	
Maximum	454.2	312.9	418,429	2,238,111	238,826	246,618	68,986	
Total, Coating Producers	7,792.3	5,674.1	16,013,704	57,517,432	10,910,495	6,348,699	1,245,640	2,822
National Total	70,719.1	33,683.3	94,232,512	176,388,898	78,976,864	19,400,836	4,144,008	2,800

for coating producers. Nationwide, emissions are expected to decline by approximately 47.6 percent.

The final column in Table 3-1 shows the cost-effectiveness of the regulation for each market segment. Overall, it costs between $2,205 and $24,410 per metric ton of HAPs removed.

Total annual costs measure the costs incurred by the industry annually. For the industry as a whole, they total approximately $94.2 million.

For batch producers of organic chemicals, the total annual cost ranges from $0 per year to $3.58 million, averaging $270,000. EPA has not estimated facility-specific costs of control for facilities producing organic chemicals using continuous processes, but the average total annual cost for the 127 facilities in the chemical manufacturing segment (assuming all incur costs) is $175,500. Estimated total annual cost for coating manufacturers ranges from $6,050 to $418,000 and averages $126,000.

SECTION 4

ECONOMIC IMPACT ANALYSIS: METHODS AND RESULTS

The proposed MACT standard requires miscellaneous organic chemical and coatings manufacturers to meet emission standards for the release of HAPs into the environment. To meet these standards, firms will have to install control devices on process vents, storage tanks, and waste water systems and to regularly search equipment components for leaks. These changes result in higher capital and operating costs for the affected producers. They also have broader societal implications because these effects are transmitted through market relationships to consumers of these products.

To measure the size and distribution of these economic impacts, the Agency compared the baseline conditions for two affected aggregate MON commodities with those for the with-regulation conditions expected to result from implementing the MACT standard. The main elements include

- a general description of the conceptual approach consistently used in previous economic analyses to estimate the impacts of MACT regulations and

- development of an economic model that characterizes aggregate baseline supply and demand for each commodity and evaluates the behavioral responses of economic agents to the regulation.

The economic model projects a price increase of MON commodities of 0.29 percent for coatings and by 0.38 percent for chemicals. Coatings manufacturers are expected to see a 0.38 percent decrease in profit. Consumers (domestic and foreign) are expected to lose $62.8 million; directly affected producers are expected to lose $31.5 million.

4.1 Conceptual Approach

The Agency conducted a market-level rather than the facility-level characterization for two markets—MON chemicals and MON coatings. The analysis was restricted to the market-level for three reasons:

- *data limitations:* The Section 114 survey responses showed a wide array of commodities potentially impacted by the regulation. However, sufficient commodity information (i.e., descriptions and particularly prices) was not available to appropriately model these markets at this level of detail.

- *use of confidential business information:* Lower levels of aggregation were not used in order to avoid disclosure of confidential business information.

- *per-unit cost screening analysis*: EPA computed the per-unit cost of regulation for each facility and this analysis suggested these costs are small and similarly distributed across industries.

Given this conclusion, the Agency considered whether producers and consumers act as price-takers in these markets (i.e., perfect competition), or whether they have some degree of market power (i.e., monopoly or oligopoly). For this analysis, EPA modeled both markets as *competitive*. The Agency concluded this assumption is appropriate given the following information:

- *product characteristics and substitution possibilities:* Limited commodity descriptions were available. However, similar SIC industry groupings were reported and used as the next best alternative to infer that the grouped products could be considered homogeneous or close substitutes.

- *empirical measures of market concentration*: The degree of competition in a market is often addressed by looking at census statistics such as the sum of the squared market shares of all firms (Herfindahl Hirschmann Index). Although definitive conclusion about market concentration cannot be drawn from this measure, HHI indices for the industry groups with the most facility observations (SIC 2851 and SIC 2869) are below 1,000. Therefore, these industries could be considered “unconcentrated” using the Department of Justices’s horizontal merger guidelines.

In competitive markets, buyers and sellers exert no individual influence on market prices. Price is set by the collective actions of producers and consumers, who take the market price as a given in making their production and consumption choices. The baseline consists of a market price and quantity that are determined by the intersection of the downward-sloping market demand curve and the upward-sloping market supply curve. With the regulation, the cost of production increases for suppliers costs associated with the installation of pollution control equipment and associated operating costs. Incorporating these costs is represented by an upward shift of the aggregate supply curve by the per-unit compliance cost. At the new equilibrium with the regulation, the market price increases and market output declines.

4.2 Operational Model

To develop quantitative estimates of economic impacts, the Agency developed an operational model using spreadsheet software. As described below and in Appendix A, this model characterizes baseline supply and demand in these two markets and the behavioral responses to changes in costs and/or market prices.

4.2.1 Market Supply

The Agency modeled these markets as having one aggregate supplier with upward-sloping supply curves, reflecting increasing marginal costs as output increases. For this analysis, the simple specification (Cobb-Douglas) was used to derive the supply curves for the aggregate producer subject to the regulation. The supply function parameters are calibrated using baseline production, price data, and assumptions about the responsiveness of supply to changes in price (supply elasticity). Absent literature estimates, EPA used a supply elasticity of 1 (i.e., a 1 percent change in the price of the commodity would result in a 1 percent increase in the supply). Sensitivity analysis was conducted in order to assess the impact of this assumption on impact estimates (see Appendix B).

4.2.2 Market Demand

EPA modeled one aggregate consumer with a downward-sloping demand curve that is consistent with the theory of demand (i.e., consumption of the commodity is high at low prices and low at high prices, reflecting the opportunity costs of purchasing these products). The Agency developed this curve using baseline quantity, price data, and assumptions about the responsiveness to changes in price (demand elasticity). For domestic demand, a demand elasticity of –0.5 was used (i.e., a 1 percent increase in the price of the commodity would result in a 0.5 percent decrease in quantity demanded, and vice versa). Sensitivity analysis was also conducted for this assumption, which is presented in Appendix B.

4.2.3 Control Cost Inputs and With-Regulation Equilibrium

Incorporating the control costs into the market model shifts the market supply curve upward by the per-unit compliance cost. In other analyses performed for the Agency, only compliance costs that vary with output levels are included in computing this shift under the assumption that only these costs affect the firm's decision regarding how much to produce. The fixed cost component of compliance costs is typically assumed to only influence a firm's decision regarding whether to operate or to exit the market. Nonetheless, an argument can be made that, prior to investing in compliance capital, the scale of these expenditures could, at least in principle, vary with the level of output. Therefore, EPA computed a parallel shift in the supply curve using the average annual *total* compliance costs for each market.

4.3 Market Model Results

The theory presented above suggests that producers attempt to mitigate the impacts of higher-cost production by shifting the burden onto other economic agents to the extent the market conditions allow. As expected the model projects upward pressure on prices as producers reduce output rates in response to higher costs. Higher prices reduce quantity demanded and output for the commodity, leading to changes in economic surplus to consumers and profitability of firms. These market adjustments determine the social costs of the regulation and its distribution across stakeholders (producers and consumers).

The model estimates impacts separately for the coatings and chemicals markets. The coatings market includes all the facilities identified as affected by EPA. Market quantity is computed by summing the quantities of MON coatings they produce. The chemicals market includes both batch chemical producers and continuous chemical producers. EPA has facility-specific quantities of MON chemicals produced by batch producers, but has no data on quantities of MON organic chemicals produced using continuous processes. In the absence of such data, EPA assumes that the quantity of MON organic chemicals produced using continuous processes is equal to the quantity using batch processes. Sensitivity analysis is performed on this assumption, and the results are presented in Appendix C. Because the data for batch producers is more complete, EPA also estimated the impacts of the proposed rule on batch processors only. These results are shown in Appendix D. An average price for each of these markets was computed based on SIC-level customs value of imports and import quantities[1] reported by the U.S. International Trade Commission (USITC, 2000).

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[1]Import quantities for these industries include different units of measure (i.e., weight [kilograms] and volume [liters]). The Section 114 responses report quantities in pounds; thus, these values were used for price calculations.

EPA believes that all domestic producers of the MON organic chemicals and coatings will be affected by the regulation. Thus, there are no domestic suppliers that would be indirectly affected by the rulemaking through changes in market price. Because EPA has only limited information on the specific products being affected by the proposed rulemaking, it was not possible to compile data on imports and exports of those commodities. Thus the market analyzes only impacts on directly regulated facilities.

4.3.1 Market-Level Impacts

The increased cost of production due to the regulation is expected to increase the price of MON commodities and reduce their production/consumption from baseline levels. As shown in Table 4-1, the regulatory alternative is projected to increase prices of coatings by less than one-half percent, 0.29 percent. The model projects chemical prices will increase by 0.38 percent. Coatings output declines by 0.14 percent, or 3.7 million pounds. Chemical output also declines by 0.19 percent, or 36.7 million pounds.

Table 4-1. Estimated Baseline Quantities and Price for the MON Markets: 1998

	Baseline	With Regulation	Absolute Change	Relative Change
Market price ($/lb)	$1.43	$1.43	$0.004	0.29%
Market quantity (10^6 lbs)	2,625	2,622	–3.7	–0.14%
Domestic	2,625	2,622	–3.7	–0.14%
Market price ($/lb)	$0.71	$0.71	$0.003	0.38%
Market quantity (10^6 lbs)	19,186	19,149	–36.7	–0.19%
Domestic	19,186	19,149	–36.7	–0.19%

4.3.2 Industry-Level Impacts

Revenue, costs, and profitability of the affected industries also change as prices and production levels adjust to increased control costs. For these producers, operating profits are projected to decline by $31.3 million (see Table 4-2), or 0.36 percent. In the coatings industry sector, revenues are estimated to increase by $5.3 million, or 0.14 percent, while costs are estimated to increase by $10.7 million, or 0.57 percent. Thus, coating manufacturers are estimated

Table 4-2. U.S. Industry-Level Impacts (10^6 1998 $/yr)

	Baseline	With Regulation	Absolute Change	Relative Change
Coatings				
Revenue	$3,754	$3,760	$5.3	0.142%
Costs	$1,877	$1,888	$10.7	0.568%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,872	–$5.3	–0.284%
Operating Profit	$1,877	$1,872	–$5.3	–0.284%
Chemicals				
Revenue	$13,622	$13,648	$26.1	0.191%
Costs	$6,811	$6,863	$52.1	0.765%
Control	NA	$78	$78.1	NA
Production	$6,811	$6,785	–$26.0	–0.382%
Operating Profit	$6,811	$6,785	–$26.0	–0.382%
Total				
Revenue	$17,376	$17,408	$31.4	0.181%
Costs	$8,688	$8,751	$62.7	0.722%
Control	NA	$94	$94.1	NA
Production	$8,688	$8,657	–$31.3	–0.361%
Operating Profit	$8,688	$8,657	–$31.3	–0.361%

to experience a decline in profits of approximately $5.3 million. In the organic chemicals sector of the industry, revenues are estimated to increase by 26.1 million, while costs are estimated to increase by $52.1 million. Thus, overall, producers of MON organic chemicals are estimated to experience decreases in profits of $26 million, or 0.38 percent.

4.4 Additional Firm-Level Analysis

Although facility-specific impacts (i.e. closures) cannot be estimated using the aggregate model described above, the Agency did conduct a screening analysis that develops limited quantitative estimates of the economic impacts on individual firms. Using this approach, producers "fully absorb" the compliance costs and their production choice is limited to compliance at the current operating rates. For each firm, the Agency computed a "sales" and "profit" test statistic to measure economic impacts of the rule. The "sales" test compares the annual compliance costs to baseline sales of the firm. The "profit" test compares annual compliance costs and baseline profit margins. Note, however, this approach excludes behavioral responses (i.e. changes in production/consumption rates and prices) that economic theory suggests will occur with changes in costs of production. Results of the firm-level analysis are presented in Section 5, and a screening analysis of small business impacts is presented in Appendix E.

4.5 Social Costs

The value of a regulatory action is traditionally measured by the change in economic welfare that it generates. The regulation's welfare impacts, or the social costs required to achieve environmental improvements, will extend to consumers and producers alike. Consumers experience welfare impacts due to changes in market prices and consumption levels associated with the rule. Producers experience welfare impacts resulting from changes in profits corresponding with the changes in production levels and market prices. However, it is important to emphasize that this measure does not include benefits that occur outside the market, that is, the value of reduced levels of air pollution with the regulation.

4.5.1 Engineering Compliance Costs

The national compliance cost estimates are often used as an approximation of the social cost of the rule. The engineering analysis estimated annual costs of $94.2 million, including $55.9 million in total annual costs for batch organic chemical facilities, $22.3 million in total annual costs for continuous organic chemical producers, and $16.0 in costs for MON coating producers. Using engineering compliance costs to estimate social costs assumes the burden of the regulation falls solely on the MON facilities that experience a profit loss exactly equal to the cost estimate. Thus, the entire loss is a change in producer surplus with no change (by assumption) in consumer surplus. This is typically referred to as a "full-cost absorption" scenario in which all factors of production are assumed to be fixed and firms are unable to adjust their output levels when faced with additional costs.

4.5.2 Estimated Social Cost

In contrast, the economic analysis accounts for behavioral responses by producers and consumers to the regulation (i.e., shifting costs to other economic agents). This approach may

Table 4-3. Distribution of the Social Costs (10^6 1998 $/yr)

Consumer Surplus	–$62.8	67%
Coatings	–$10.7	
Chemicals	–$52.1	
Producer Surplus	–$31.3	33%
Coatings	–$5.3	
Chemicals	–$26.0	
Total Social Cost	–$94.1	

result in a social cost estimate that differs from the engineering estimate and also provides insights on how the regulatory burden is distributed across stakeholders. As shown in Table 4-3, the economic model estimates a slightly smaller total social cost of the rule of $94.1 million. Consumers (domestic and foreign) are projected to lose $62.8 million, and directly affected producers lose $31.5 million. (Note that in the case of the market for MON commodities, consumers are generally other producers of intermediate or final goods.)

SECTION 5

SMALL BUSINESS IMPACT ANALYSIS

This regulatory action will potentially affect the economic welfare of owners of facilities that manufacture coatings and other miscellaneous organic chemicals. The ownership of these facilities ultimately falls on private individuals who may be owners/operators that directly conduct the business of the firm (i.e., single proprietorships or partnerships) or, more commonly, investors or stockholders that employ others to conduct the business of the firm on their behalf (i.e., privately held or publicly traded corporations). The individuals or agents that manage these facilities have the capacity to conduct business transactions and make business decisions that affect the facility. The legal and financial responsibility for compliance with a regulatory action ultimately rests with these agents; however, the owners must bear the financial consequences of the decisions. Environmental regulations like this rule potentially affect all businesses, large and small, but small businesses may have special problems in complying with such regulations.

The Regulatory Flexibility Act (RFA) of 1980 requires that special consideration be given to small entities affected by federal regulation. The RFA was amended in 1996 by the Small Business Regulatory Enforcement Fairness Act (SBREFA) to strengthen the RFA's analytical and procedural requirements. Prior to enactment of SBREFA, EPA exceeded the requirements of the RFA by requiring the preparation of a regulatory flexibility analysis for every rule that would have any impact, no matter how minor, on any number, no matter how few, of small entities. Under SBREFA, however, the Agency decided to implement the RFA as written and that a regulatory flexibility analysis will be required only for rules that will have a *significant* impact on a *substantial* number of small entities (SISNOSE). In practical terms, the amount of analysis of small entities' impacts has not changed, for SBREFA required EPA to increase involvement of small entity stakeholders in the rulemaking process. Thus the Agency has made additional efforts to consider small entity impacts as part of the rulemaking process.

5.1 Identifying Small Businesses

As described in Section 2 of this report, the Agency identified a substantial number of small businesses potentially affected by the proposed rule. Based on SBA employee size definitions, 72 (40 percent) of the 181 affected companies can be classified as small.

5.2 Screening-Level Analysis

Prior to completing the economic analysis, the Agency completed a preliminary screening-level analysis to assist in determining whether this rule is likely to impose a significant impact on a substantial number of small businesses. The analysis employed a "sales test," which computed the annualized compliance costs as a share of sales for each company. The annual compliance costs were defined as the engineering control costs imposed on facilities owned by these companies (see Table 5-1). Only costs imposed on facilities producing coatings or producing chemicals using batch processes were calculated by facility. Costs imposed on continuous production processes were estimated as a lump sum cost. Since the Miscellaneous Organic Chemicals NESHAP will consist of two regulations, one for coatings manufacturers and one for manufacturers of other miscellaneous organic chemicals, the Agency has estimated the small business impacts of those regulations separately.

Table 5-1. Total Annual Costs for Complying with MON: February 1999

Number of Facilities	Type of Facility	Total Annual Costs ($)
127	Coatings manufacturing	$16,013,704
207	Batch process manufacturing of miscellaneous organic chemicals other than coatings	$55,930,257
140[a]	Continuous process manufacturing of miscellaneous organic chemicals other than coatings	$22,288,551

Note: Some facilities are engaged in more than one type of production process, so the total number of facilities above is greater than the actual number of facilities.

[a] Based on the number of facilities in the database designated as producing chemicals using continuous processes.

Appendix E presents two sensitivity analyses, one that considers the combined impacts of the two regulations and another that examines the effects of the regulation of batch production processes only.

5.2.1 Effects of the Regulation of Coatings Manufacturers

Table 5-2 reports total compliance costs of the regulation on facilities that manufacture coatings, the number of companies affected at the 1 percent and 3 percent levels, and summary statistics of the cost-to-sales ratios (CSRs) of small companies. Figures 5-1(a) and 5-1(b) illustrate the distribution of these ratios across small and large companies with sales data.

The aggregate compliance costs of the regulation for facilities producing coatings total $3.8 million for small businesses (see Table 5-2). Thirty-two (44 percent) of the 72 small companies affected by the miscellaneous organic chemical NESHAP own facilities that manufacture coatings. RTI obtained sales data for 30 of the 32 small companies that own coating facilities, or 94 percent. For these companies, the annual compliance costs for small businesses range from 0.08 to 7.74 percent of sales. The average (median) compliance CSR is 1.02 (0.50) percent for the identified small businesses with sales data. As shown, five small companies are affected at the 1 percent to 3 percent level and two small companies are affected at the 3 percent level. In contrast, only one out of the 26 large companies that own facilities affected by this regulation will find compliance costs to be greater than 1 percent of sales.

The effect of cost increases is best understood in the context of the change in profit margin that will result from the regulation. Table 5-3 shows that the average and median profit margins of firms owning facilities that produce coatings will decrease more for small firms than for large firms. Figures 5-2(a) and (b) show the distribution of profit margins for small and large firms under regulation.

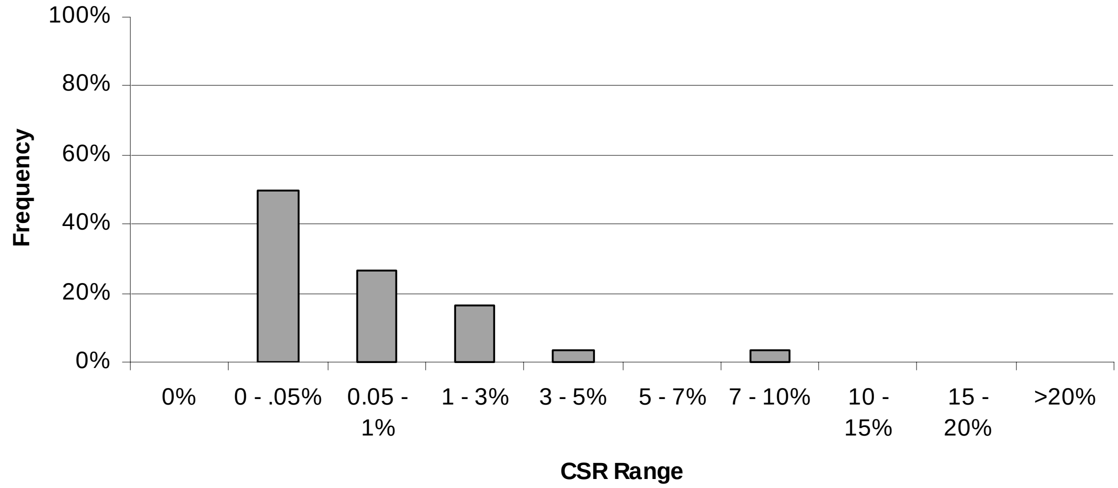
5.2.2 Effects of the Regulation of Chemical Manufacturers

As specified in the introduction to this section, there are two different types of production processes for miscellaneous organic chemicals—batch processes and continuous processes. Engineers itemized the compliance costs applicable to batch production processes by facility. However, the compliance costs applicable to continuous production processes

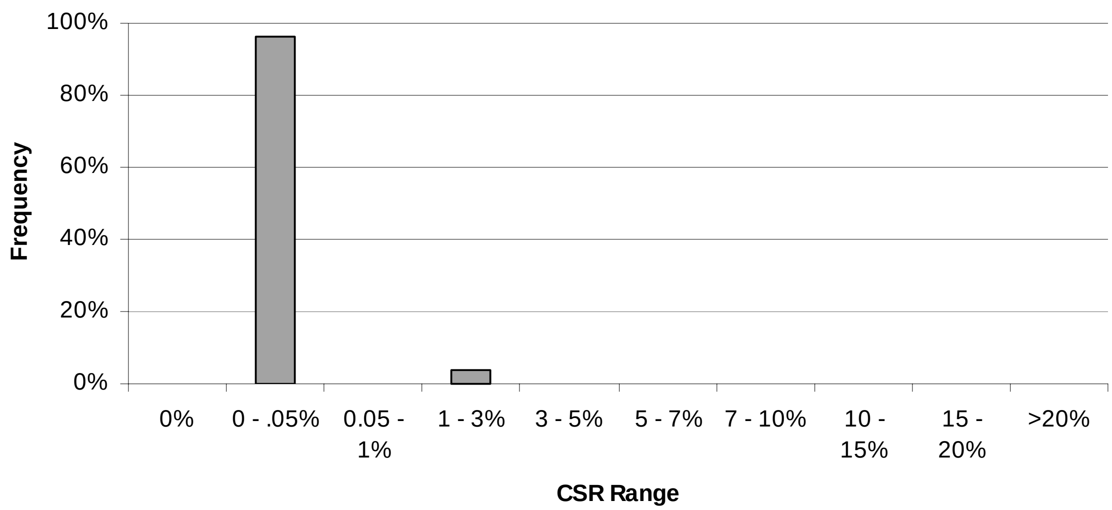
Table 5-2. Summary Statistics for SBREFA Screening Analysis: MON—Regulation of Coating Facilities: 1998

	Small		Large		All Companies	
Total number of companies	32		26		58	
Annual compliance costs ($\$10^6$/yr)	\$3.8		\$12.2		\$16.0	
	Number	Share[a]	Number	Share	Number	Share[a]
Companies with sales data	30		26		56	
Compliance costs are <1% of sales	23	77%	25	96%	48	86%
Compliance costs are ≥1 to 3% of sales	5	17%	1	4%	6	11%
Compliance costs are ≥3% of sales	2	7%	0	0%	2	4%
Compliance cost-to-sales ratios						
Average	1.02%		0.10%		0.60%	
Median	0.50%		0.03%		0.17%	
Maximum	7.74%		1.45%		7.74%	
Minimum	0.08%		0.00%		0.00%	

Note: Assumes no market responses (i.e., price and output adjustments) by regulated entities.
[a] Total is greater than 100 due to rounding.



(a) Small Companies



(b) Large Companies

Figure 5-1. Distribution of Cost-to-Sales Ratios

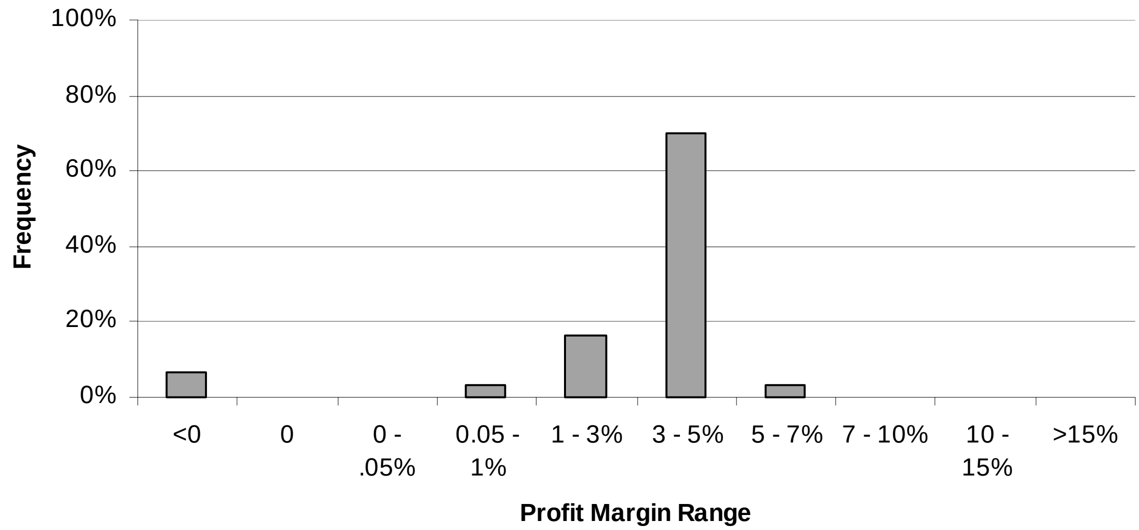
Table 5-3. Profit Margins With and Without Regulation of Coatings Manufacturers

	Small Companies	Large Companies	All Companies
Profit margins without regulation			
Average	2.74%	4.92%	3.75%
Median	2.70%	3.85%	2.70%
Maximum	5.10%	15.05%	15.05%
Minimum	–0.24%	1.59%	–0.24%
Number of firms with profit margin less than zero	1	0	1
Profit margins with regulation			
Average	1.71%	4.82%	3.16%
Median	2.70%	3.85%	2.70%
Maximum	5.10%	15.05%	15.05%
Minimum	–0.24%	1.59%	–0.24%
Number of firms with profit margin less than zero	4	0	4

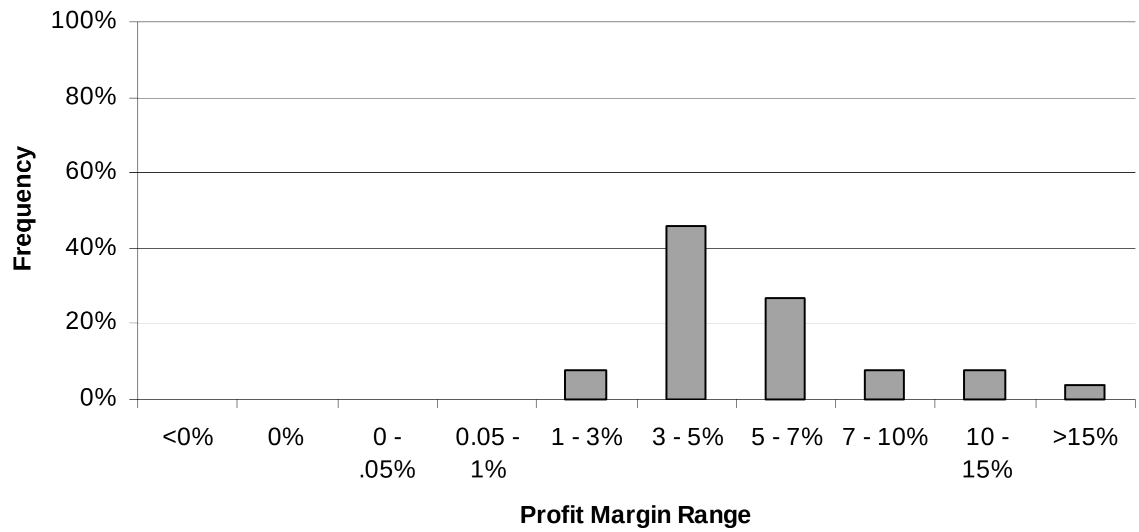
were estimated as a lump sum cost to be borne by a total of 140 facilities. To estimate the total effects of the regulation of chemical manufacturers, the Agency divided the compliance costs imposed on continuous production processes ($22,288,551) among the 140 facilities.

Table 5-4 reports total compliance costs of the regulation of facilities that manufacture miscellaneous organic chemicals not used as coatings. The table also shows the number of companies affected at the 1 percent and 3 percent levels and summary statistics of the CSRs of small companies. Figures 5-3(a) and 3(b) illustrate the distribution of these ratios across small and large companies with sales data.

The aggregate compliance costs of the regulation of facilities producing miscellaneous chemicals total $8.9 million for small businesses (see Table 5-4). Forty-six (64 percent) of the 72 small companies affected by the miscellaneous organic chemical NESHAP own facilities that manufacture organic chemicals other than coatings. RTI obtained sales data for 41 of the 46 small companies owning chemical facilities, or 89 percent. For these companies, the annual compliance costs for small businesses range from



(a) Small Companies



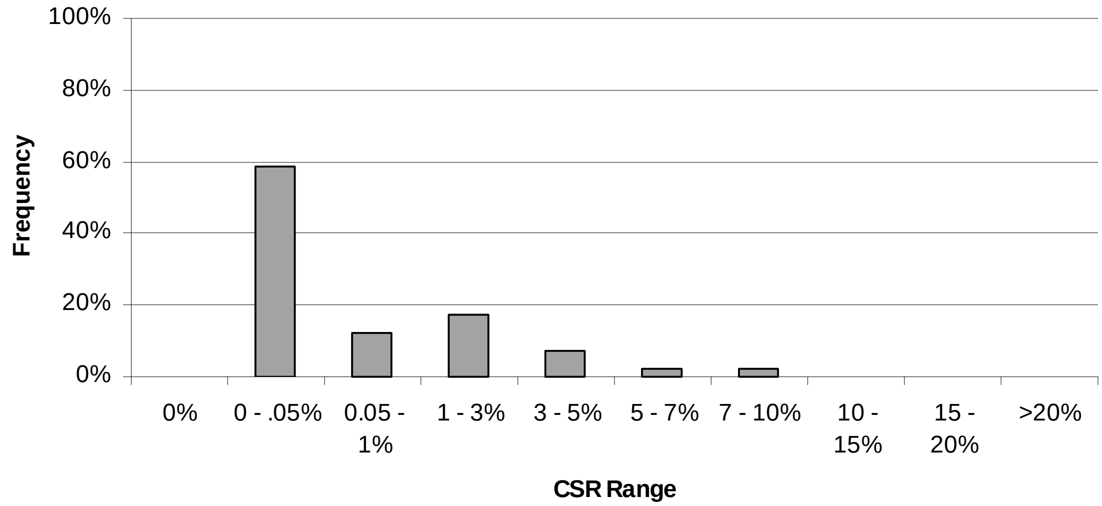
(b) Large Companies

Figure 5-2. Distribution of Profit Margins

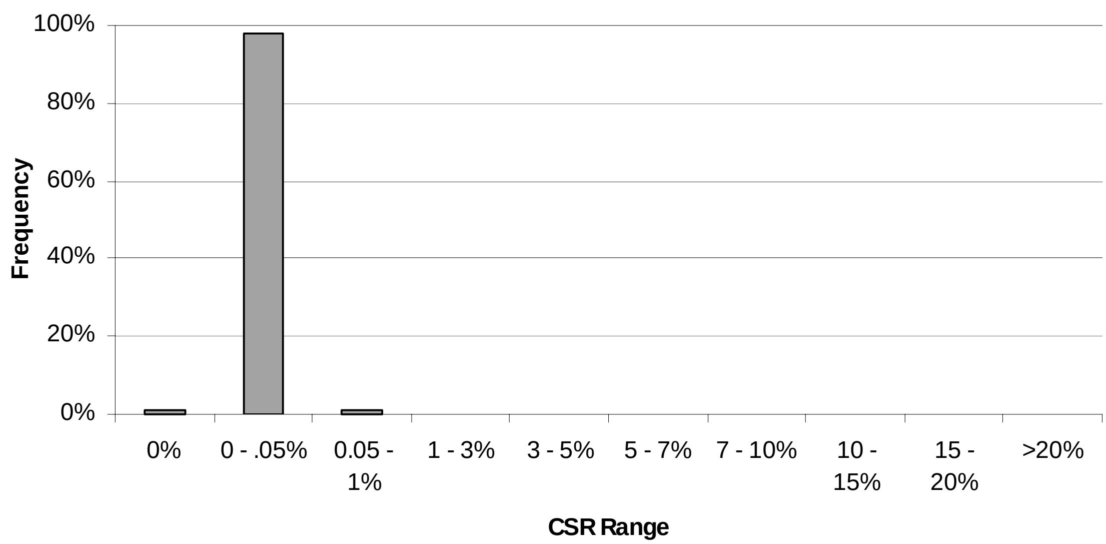
Table 5-4. Summary Statistics for SBREFA Screening Analysis: Impacts of the Regulation of Other Miscellaneous Organic Chemical Manufacturers using Batch and/or Continuous Production Processes

	Small		Large		All Companies	
Total number of companies	46		102		148	
Annual compliance costs ($\$10^6$/yr)	\$8.9		\$69.8		\$78.7	
	Number	Share	Number	Share	Number	Share
Companies with sales data	41		102		143	
Compliance costs are <1% of sales	29	71%	102	100%	131	92%
Compliance costs are ≥1 to 3% of sales	7	17%	0	0%	7	5%
Compliance costs are ≥3% of sales	5	12%	0	0%	5	3%
Compliance cost-to-sales ratios						
Average	1.13%		0.04%		0.36%	
Median	0.37%		0.02%		0.03%	
Maximum	9.32%		0.51%		9.32%	
Minimum	0.00%		0.00%		0.00%	

Note: Assumes no market responses (i.e., price and output adjustments) by regulated entities.



(a) Small Companies



(b) Large Companies

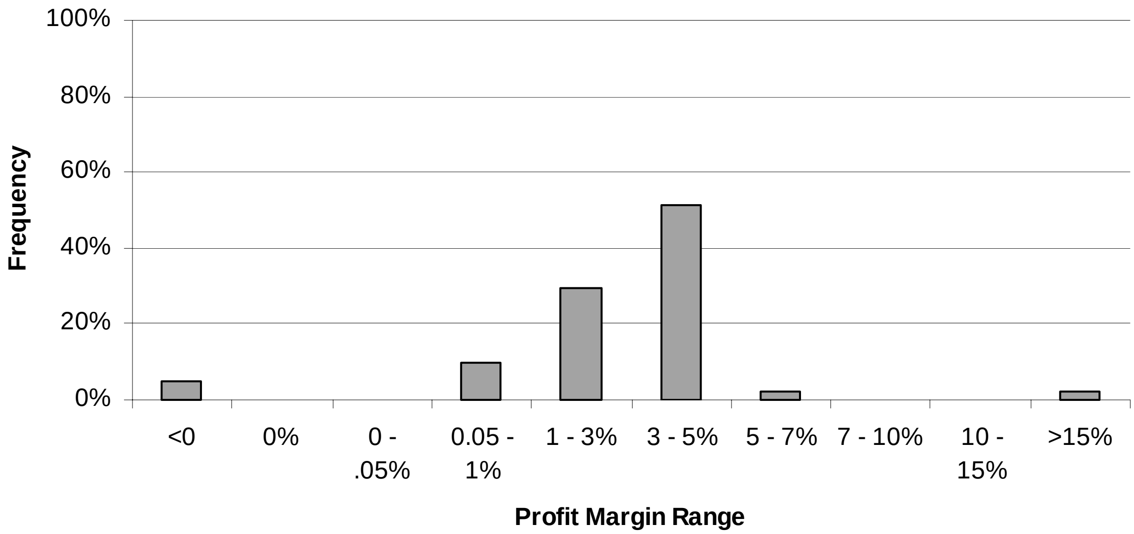
Figure 5-3. Distribution of Cost-to-Sales Ratios

0 to 9.32 percent of sales. The average (median) compliance CSR is 1.13 (0.37) percent for the identified small businesses with sales data. As shown, seven small companies are affected at the 1 percent to 3 percent level and five small companies are affected at the 3 percent level. In contrast, none of the 102 large companies that own facilities affected by the chemical manufacturing regulation will find compliance costs to be greater than 1 percent of sales.

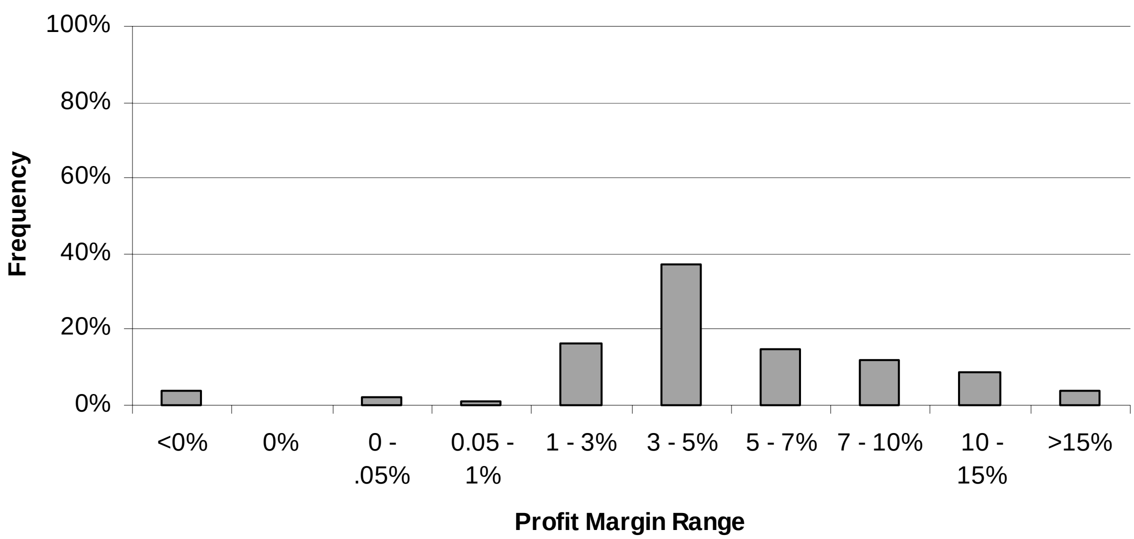
Table 5-5 shows that the average and median profit margins of firms owning facilities that produce coatings will decrease more for small firms than for large firms. Figure 5-4(a) and (b) show the distribution of profit margins for small and large firms under the regulation.

Table 5-5. Profit Margins With and Without Regulation of Manufacturers of Other Miscellaneous Organic Chemicals using Batch and/or Continuous Production Processes

	Small Companies	Large Companies	All Companies
Profit margins without regulation			
Average	4.30%	5.96%	5.48%
Median	4.00%	4.50%	4.50%
Maximum	18.53%	82.74%	82.74%
Minimum	2.70%	–13.92%	–13.92%
Number of firms with profit margin less than zero	0	4	4
Profit margins with regulation			
Average	3.17%	5.91%	5.13%
Median	3.43%	4.48%	4.20%
Maximum	18.52%	82.73%	82.73%
Minimum	–6.62%	–13.95%	–13.95%
Number of firms with profit margin less than zero	2	4	6



(a) Small Companies



(b) Large Companies

Figure 5-4. Distribution of Profit Margins With Regulation

5.3 Summary Assessment

The RFA generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute, unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impacts of today's rule on small entities, small entity is defined as (1) a small business according to Small Business Administration size standards by 4-digit SIC of the owning entity (in this case, ranging from 500 to 1,000 employees); (2) a small governmental jurisdiction that is a government of a city, county, town, school district, or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

After considering the economic impact of today's proposed rule on small entities, I certify that this action will not have a significant impact on a substantial number of small entities. In accordance with the RFA, as amended by the SBREFA, 5 U.S.C. 601, *et. seq.*, EPA conducted an assessment of the proposed standard on small business within the industries affected by the rule. Based on SBA size definitions for the affected industries and reported sales and employment data, the Agency identified 32 of the 58 companies, or 55 percent, owning affected coating manufacturing facilities as small businesses. Although small businesses represent 55 percent of the companies within the source category, they are expected to incur only 24 percent of the total industry compliance costs of $16 million. There are only two small firms with compliance costs equal to or greater than 3 percent of their sales. In addition, there are only five small firms with cost-to-sales ratios between 1 and 3 percent.

An economic impact analysis was performed to estimate the changes in product price and production quantities for the coating manufacturing firms affected by this rule. The analysis shows that of the 70 facilities owned by affected small firms, only three are expected to shut down in response to the implementation of the proposed rule. Hence, it seems reasonable to conclude that the closures will not lead to a significant economic impact due to the small reduction in facilities owned by affected small firms.

This analysis indicates that the proposed rule should not generate a significant impact on a substantial number of small entities for the coatings manufacturing source category for the following reasons. First, there are only seven small firms (or 22 percent of all affected small firms) with compliance costs equal to or greater than 1 percent of their sales. In addition, there are only two small firms (or 6 percent of all affected small firms)with compliance costs equal to or greater than 3 percent of their sales. Second, the results of the economic impact analysis show that only three facilities owned by a small business may close due to the implementation of this rule**.** It should be noted that the baseline economic condition of the facility predicted to close affects the closure estimate provided by the economic model (i.e., facilities that are already experiencing adverse economic conditions will be more severely impacted than those that are not, and that the facility predicted to close appears to currently have low profitability). This analysis therefore allows us to certify that there will not be a significant impact on a substantial number of small entities from the implementation of this proposed rule. For more information, consult the docket for this project.

As for the chemical manufacturing source category, based on SBA size definitions for the affected industries and reported sales and employment data, the Agency identified 27 of the 113 companies, or 24 percent, owning affected chemical manufacturing facilities as small businesses. Although small businesses represent 24 percent of the companies within the source category, they are expected to incur only 6 percent of the total industry compliance costs of $78 million. There is only one small firm with compliance costs equal to or greater than 3 percent of its sales. In addition, there are only three small firms with cost-to-sales ratios between 1 and 3 percent.

An economic impact analysis was performed to estimate the changes in product price and production quantities for the firms affected by this rule. The analysis shows that of the 49 facilities owned by affected small firms, only two are expected to shut down in response to the implementation of the proposed rule. Hence, it seems reasonable to conclude that the closure will not lead to a significant economic impact due to the small reduction in facilities owned by affected small firms.

This analysis indicates that the proposed rule should not generate a significant impact on a substantial number of small entities for the chemical manufacturing source category for the following reasons. First, there are only four small firms (or 15 percent of all affected small firms) with compliance costs equal to or greater than 1 percent of their sales. In addition, there is only one small firm (or 4 percent of all affected small firms)with compliance costs equal to or greater than 3 percent of its sales. Second, the results of the economic impact analysis show that only two facilities may close due to the implementation of this rule. It should be noted that the baseline economic condition of the facility predicted to close affects the closure estimate provided by the economic model (i.e., facilities that are already experiencing adverse economic conditions will be more severely impacted than those that are not, and that the facility predicted to close appears to currently have low profitability). This analysis therefore allows us to certify that there will not be a significant impact on a substantial number of small entities in the chemical manufacturing source category from the implementation of this proposed rule. For more information, consult the docket for this project.

Although this proposed rule will not have a significant economic impact on a substantial number of small entities, the EPA nonetheless has tried to limit the impact of this rule on small entities. We continue to be interested in the potential impacts of the proposed rule on small entities and welcome comments on issues related to such impacts.

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Appendix A

MON Economic Model

RTI will develop an economic model for two MON markets (chemicals and coatings) to estimate the economic impacts of the proposed rule. This appendix describes the proposed model in detail and discusses how RTI will

- characterize the supply of the affected commodities at the market level,
- characterize demand, and
- use a solution algorithm to determine the new with-regulation equilibrium.

A.1 Baseline Data Set

RTI collected the following information in order to characterize the baseline:

- *market quantities:* Data for more than 300 facilities were aggregated to develop baseline market quantities for the chemical and coatings markets (see Table A-1).
- *market prices:* An average price for each of these markets was computed based on SIC-level customs value of imports and import quantities[1] reported by the U.S. International Trade Commission (USITC, 2000).

Table A-1. Baseline Data Set: 1998

Market	Average Price ($/lb)	Quantity (10^9 lbs)
Chemical	$0.71	9.59
Coatings	$1.43	2.63

A.2 Market Supply

Chemical and coatings producers subject to the regulation have some ability to vary output in the face of production cost changes. Their production cost curves, coupled with the market price, could be used to determine the optimal production rate. RTI will model supply as a single representative supplier with the following supply characterization:

[1]Import quantities for these industries include different units of measure (i.e., weight [kilograms] and volume [liters]). The Section 114 responses report quantities in pounds; thus, these values were used for price calculations.

$$Q_{Si} = A_{Si} [p_i]^{\varepsilon_S} \tag{A.1}$$

In this Cobb-Douglas specification, p_i is the market price for the ith market, ε_{Si} is the domestic supply elasticity (assumed value = 1), and A_{Si} is a multiplicative supply parameter that calibrates the supply equation to replicate the aggregate production obtained from survey responses.

Regulation-Induced Shift in the Supply Function. The control costs associated with the proposed NESHAP total $78.2 million for the chemical market and $16.0 for the coatings market (see Table A-2). The estimated annual compliance cost per pound (c_i) enters the supply equation as a net price change (i.e., $p_i - c_i$). Thus, the supply function from Eq. (A.1) becomes:

$$Q_{Si} = A_{Si} [p_i - c_i]^{\varepsilon_{Si}} \tag{A.2}$$

Table A-2. Computing Regulatory-Induced Shift in Supply Function: 1998

Market	Total Annual Costs ($$10^6$)	Per-Unit "Cost-Shifter"	% Shift
Chemical	$78.2	$0.008	1.14%
Coatings	$16.0	$0.006	0.43%

A.3 Market Demand

Demand will be expressed as

$$Q_{Di} = A_{Di} [p_i]^{\varepsilon_{Di}} \tag{A.3}$$

where p_i is the market price, ε_{Di} is the demand elasticity, and A_{Di} is a multiplicative demand parameter that calibrates the demand equation, given data on price and the demand elasticity to replicate the observed baseline year level of consumption (assumed to equal production).

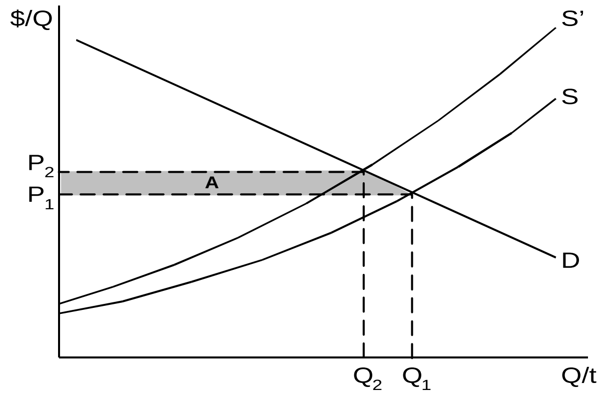
A.4 With-Regulation Market Equilibrium

Supply/demand responses can be conceptualized as an interactive feedback process. Producers face increased production costs due to compliance and respond with output reduction. This leads to an increase in the market price that both types of producers (directly affected and indirectly affected) and consumers face. This increase leads to further responses by all producers and consumers and, thus, new market prices. The new with-regulation equilibrium is the result of a series of these iterations between producer and consumer responses and market adjustments until a stable market price equilibrium is reached in which total market supply equals total market demand (i.e., $Q_S = Q_D$).

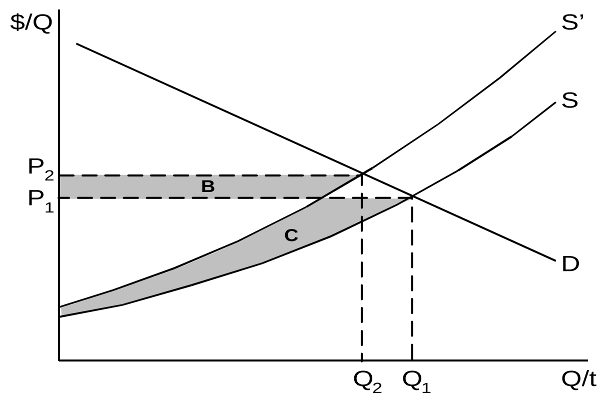
A.5 Economic Welfare Impacts

The economic welfare implications of the market price and output changes with the regulation can be examined as changes in the net benefits of consumers and producers based on the price changes. This analysis focuses on the changes in the net benefits of consumers and producers. Figure A-1 depicts the change in economic welfare by first measuring the change in consumer surplus and then the change in producer surplus. In essence, the demand and supply curves previously used as predictive devices are now being used as a tool to measure changes in economic welfare.

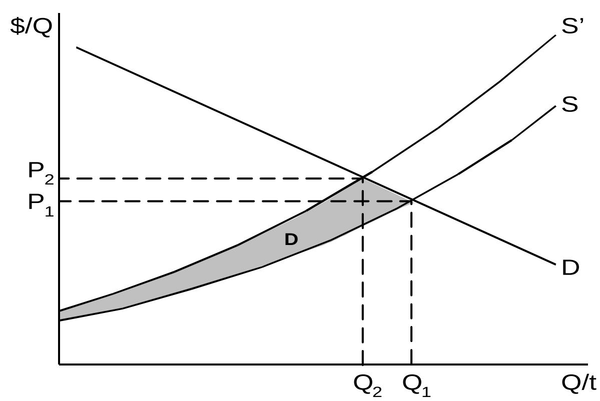
In a market environment, consumers and producers of the good or service derive welfare from a market transaction. The difference between the maximum price consumers are willing to pay for a good and the price they actually pay is referred to as "consumer surplus." Consumer surplus is measured as the area under the demand curve and above the price of the product. Similarly, the difference between the minimum price producers are willing to accept for a good and the price they actually receive is referred to as "producer surplus" or profits. Producer surplus is measured as the area above the supply curve and below the price of the product. These areas can be thought of as consumers' net benefits of consumption and producers' net benefits of production, respectively. In Figure A-1, baseline equilibrium occurs at the intersection of the demand curve, D, and supply curve, S. Price is P_l with quantity Q_l. The increased cost of production with the



(a) Change in Consumer Surplus with Regulation



(b) Change in Producer Surplus with Regulation



(c) Net Change in Economic Welfare with Regulation

Figure A-1. Economic Welfare Changes with Regulation: Consumer and Producer Surplus

regulation will cause the market supply curve to shift upward to S′. The new equilibrium price of the product is P_2. With a higher price for the product, there is less consumer welfare, all else being unchanged as real incomes are reduced. In Figure A-1(a), area A represents the dollar value of the annual net loss in consumers' benefits with the increased price. The rectangular portion represents the loss in consumer surplus on the quantity still consumed, Q_2, while the triangular area represents the foregone surplus resulting from the reduced quantity consumed, Q_1–Q_2.

In addition to the changes in consumer welfare, producer welfare also changes with the regulation. With the increase in market price, producers receive higher revenues on the quantity still purchased, Q_2. In Figure A-1(b), area B represents the increase in revenues due to this increase in price. The difference in the area under the supply curve up to the original market price, area C, measures the loss in producer surplus, which includes the loss associated with the quantity no longer produced. The net change in producer welfare is represented by area B–C. The change in economic welfare attributable to the compliance costs of the regulation is the sum of consumer and producer surplus changes, that is, – (A) + (B–C). Figure A-1(c) shows the net (negative) change in economic welfare associated with the regulation as area D. However, this analysis does not include the benefits that occur outside the market (i.e., the value of the reduced levels of air pollution with the regulation). Including this benefit will reduce the net social cost of the regulation.

Appendix B

Sensitivity Analysis of Assumed Elasticities of Demand and Supply

EPA has estimated that the elasticity of demand for MON chemicals and coatings is –0.5. The Agency expects the demand to be relatively inelastic because the commodities being produced are typically inputs to other production processes, and may be relatively small cost shares of the final products they are ultimately embodied in. EPA has assumed that the elasticity of supply is 1.

This Appendix presents a sensitivity analysis of these assumptions, varying the demand elasticity and the supply elasticity by 25 percent in either direction.

Table B-1. Market Level Impacts (continuous product = batch production, demand elasticity = –0.6, supply elasticity = 1)

	Baseline	With Reg	Change	
			Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.263%
Quantity (lb)	2,625	2,621	–4.3	–0.164%
Directly Affected: Domestic	2,625	2,621	–4.3	–0.164%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.003	0.354%
Quantity (lb)	19,186	19,144	–42.3	–0.220%
Directly Affected: Domestic	19,186	19,144	–42.3	–0.220%

Table B-2. Industry-Level Impacts (continuous product = batch production, demand elasticity = –0.6, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,758	$3.7	0.098%
Costs	$1,877	$1,887	$9.8	0.524%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,871	–$6.1	–0.327%
Operating Profit	$1,877	$1,871	–$6.1	–0.327%
Chemicals				
Revenue	$13,622	$13,640	$18.1	0.133%
Costs	$6,811	$6,859	$48.0	0.705%
Control	NA	$78	$78.0	NA
Production	$6,811	$6,781	–$30.0	–0.440%
Operating Profit	$6,811	$6,781	–$30.0	–0.440%
Total				
Revenue	$17,376	$17,398	$21.7	0.125%
Costs	$8,688	$8,746	$57.9	0.666%
Control	NA	$94	$94.0	NA
Production	$8,688	$8,652	–$36.1	–0.416%
Operating Profit	$8,688	$8,652	–$36.1	–0.416%

Table B-3. Distribution of Social Costs ($) (continuous product = batch production, demand elasticity = –0.6, supply elasticity = 1)

Consumer Surplus	–$58.0	
Coatings	–$9.9	62%
Chemicals	–$48.1	
Producer Surplus	–$36.1	
Coatings	–$6.1	38%
Chemicals	–$30.0	
Total Social Cost	–94.1	

Table B-4. Market Level Impacts (continuous product = batch production, demand elasticity = –0.4, supply elasticity = 1)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.310%
Quantity (lb)	2,625	2,622	–3.0	–0.116%
Directly Affected: Domestic	2,625	2,622	–3.0	–0.116%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.003	0.418%
Quantity (lb)	19,186	19,156	–30.0	–0.156%
Directly Affected: Domestic	19,186	19,156	–30.0	–0.156%

Table B-5. Industry-Level Impacts (continuous product = batch production, demand elasticity = –0.4, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,762	$7.3	0.194%
Costs	$1,877	$1,889	$11.6	0.620%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,873	–$4.4	–0.232%
Operating Profit	$1,877	$1,873	–$4.4	–0.232%
Chemicals				
Revenue	$13,622	$13,658	$35.6	0.261%
Costs	$6,811	$6,868	$56.8	0.834%
Control	NA	$78	$78.1	NA
Production	$6,811	$6,790	–$21.3	–0.312%
Operating Profit	$6,811	$6,790	–$21.3	–0.312%
Total				
Revenue	$17,376	$17,419	$42.8	0.246%
Costs	$8,688	$8,757	$68.5	0.788%
Control	NA	$94	$94.1	NA
Production	$8,688	$8,663	–$25.6	–0.295%
Operating Profit	$8,688	$8,663	–$25.6	–0.295%

Table B-6. Distribution of Social Costs ($) (continuous product = batch production, demand elasticity = –0.4, supply elasticity = 1)

Consumer Surplus	–$68.5	
Coatings	–$11.6	73%
Chemicals	–$56.9	
Producer Surplus	–$25.6	
Coatings	–$4.4	27%
Chemicals	–$21.3	
Total Social Cost	–94.2	

Table B-7. Market Level Impacts (continuous product = batch production, demand elasticity = –0.5, supply elasticity = 1.25)

			Change	
	Baseline	With Reg	Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.305%
Quantity (lb)	2,625	2,621	–4.0	–0.152%
Directly Affected: Domestic	2,625	2,621	–4.0	–0.152%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.003	0.410%
Quantity (lb)	19,186	19,147	–39.3	–0.205%
Directly Affected: Domestic	19,186	19,147	–39.3	–0.205%

Table B-8. Industry-Level Impacts (continuous product = batch production, demand elasticity = –0.5, supply elasticity = 1.25)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,760	$5.7	0.152%
Costs	$2,086	$2,096	$10.3	0.493%
Control	NA	$16	$16.0	NA
Production	$2,086	$2,080	–$5.7	–0.274%
Operating Profit	$1,669	$1,664	–$4.6	–0.274%
Chemicals				
Revenue	$13,622	$13,650	$27.9	0.205%
Costs	$7,568	$7,618	$50.2	0.663%
Control	NA	$78	$78.1	NA
Production	$7,568	$7,540	–$27.8	–0.368%
Operating Profit	$6,054	$6,032	–$22.3	–0.368%
Total				
Revenue	$17,376	$17,410	$33.6	0.194%
Costs	$9,654	$9,714	$60.5	0.627%
Control	NA	$94	$94.0	NA
Production	$9,654	$9,620	–$33.6	–0.348%
Operating Profit	$7,723	$7,696	–$26.8	–0.348%

Table B-9. Distribution of Social Costs ($) (continuous product = batch production, demand elasticity = –0.5, supply elasticity = 1.25)

Consumer Surplus	–$67.3	
Coatings	–$11.4	71%
Chemicals	–$55.9	
Producer Surplus	–$26.8	
Coatings	–$4.6	29%
Chemicals	–$22.3	
Total Social Cost	–94.1	

Table B-10. Market Level Impacts (continuous product = batch production, demand elasticity = –0.5, supply elasticity = 0.75)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.256%
Quantity (lb)	2,625	2,622	–3.4	–0.128%
Directly Affected: Domestic	2,625	2,622	–3.4	–0.128%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.002	0.345%
Quantity (lb)	19,186	19,153	–33.0	–0.172%
Directly Affected: Domestic	19,186	19,153	–33.0	–0.172%

Table B-11. Industry-Level Impacts (continuous product = batch production, demand elasticity = –0.5, supply elasticity = 0.75)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,759	$4.8	0.128%
Costs	$1,609	$1,620	$11.2	0.696%
Control	NA	$16	$16.0	NA
Production	$1,609	$1,604	–$4.8	–0.298%
Operating Profit	$2,145	$2,139	–$6.4	–0.298%
Chemicals				
Revenue	$13,622	$13,646	$23.5	0.172%
Costs	$5,838	$5,893	$54.7	0.937%
Control	NA	$78	$78.1	NA
Production	$5,838	$5,815	–$23.4	–0.401%
Operating Profit	$7,784	$7,753	–$31.2	–0.401%
Total				
Revenue	$17,376	$17,405	$28.3	0.163%
Costs	$7,447	$7,513	$65.9	0.885%
Control	NA	$94	$94.1	NA
Production	$7,447	$7,419	–$28.2	–0.379%
Operating Profit	$9,929	$9,892	–$37.6	–0.379%

Table B-12. Distribution of Social Costs ($) (continuous product = batch production, demand elasticity = –0.5, supply elasticity = 0.75)

Consumer Surplus	–$56.6	
Coatings	–$9.6	60%
Chemicals	–$46.9	
Producer Surplus	–$37.6	
Coatings	–$6.4	40%
Chemicals	–$31.2	
Total Social Cost	–94.2	

Appendix C

Sensitivity Analysis of Assumed Quantity of MON Chemicals Produced Using Continuous Processes

EPA has no data on the quantity of MON organic chemicals produced using continuous production processes. In the main body of the report, EPA has assumed that the quantity of MON organic chemicals produced using continuous production processes is exactly equal to that produced using batch processes.

This Appendix presents a sensitivity analysis of these assumptions, varying the quantity of MON organic chemicals produced using continuous processes by 50 percent in either direction. The results of the sensitivity analysis are shown in the following tables. Tables C-1 through C-5 present the results of the model assuming that continuous chemical production is half that of batch production, and varying the supply and demand elasticities as discussed in Appendix B. Tables C-6 through C-10 show the model results assuming that continuous chemical production is 1.5 times that of batch processes, and varying the supply and demand elasticities as discussed in Appendix B.

Table C-1. Market Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 1)

	Baseline	With Reg	Change: Absolute	Change: Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.285%
Quantity (lb)	2,625	2,622	–3.7	–0.142%
Directly Affected: Domestic	2,625	2,622	–3.7	–0.142%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.511%
Quantity (lb)	14,390	14,353	–36.6	–0.255%
Directly Affected: Domestic	14,390	14,353	–36.6	–0.255%

Table C-2. Industry-Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,760	$5.3	0.142%
Costs	$1,877	$1,888	$10.7	0.568%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,872	–$5.3	–0.284%
Operating Profit	$1,877	$1,872	–$5.3	–0.284%
Chemicals				
Revenue	$10,217	$10,243	$26.1	0.255%
Costs	$5,108	$5,160	$52.0	1.019%
Control	NA	$78	$78.0	NA
Production	$5,108	$5,082	–$26.0	–0.508%
Operating Profit	$5,108	$5,082	–$26.0	–0.508%
Total				
Revenue	$13,971	$14,002	$31.4	0.225%
Costs	$6,985	$7,048	$62.7	0.898%
Control	NA	$94	$94.0	NA
Production	$6,985	$6,954	–$31.3	–0.448%
Operating Profit	$6,985	$6,954	–$31.3	–0.448%

Table C-3. Distribution of Social Costs ($) (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 1)

Consumer Surplus	–$62.8	
Coatings	–$10.7	67%
Chemicals	–$52.1	
Producer Surplus	–$31.3	
Coatings	–$5.3	33%
Chemicals	–$26.0	
Total Social Cost	–$94.1	

Table C-4. Market Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.6, supply elasticity = 1)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.263%
Quantity (lb)	2,625	2,621	–4.3	–0.164%
Directly Affected: Domestic	2,625	2,621	–4.3	–0.164%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.003	0.472%
Quantity (lb)	14,390	14,347	–42.3	–0.294%
Directly Affected: Domestic	14,390	14,347	–42.3	–0.294%

Table C-5. Industry-Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.6, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,758	$3.7	0.098%
Costs	$1,877	$1,887	$9.8	0.524%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,871	–$6.1	–0.327%
Operating Profit	$1,877	$1,871	–$6.1	–0.327%
Chemicals				
Revenue	$10,217	$10,235	$18.1	0.177%
Costs	$5,108	$5,156	$48.0	0.940%
Control	NA	$78	$78.0	NA
Production	$5,108	$5,078	–$30.0	–0.587%
Operating Profit	$5,108	$5,078	–$30.0	–0.587%
Total				
Revenue	$13,971	$13,993	$21.7	0.156%
Costs	$6,985	$7,043	$57.9	0.828%
Control	NA	$94	$94.0	NA
Production	$6,985	$6,949	–$36.1	–0.517%
Operating Profit	$6,985	$6,949	–$36.1	–0.517%

Table C-6. Distribution of Social Costs ($) (continuous product = 0.5 * batch production, demand elasticity = –0.6, supply elasticity = 1)

Consumer Surplus	–$58.0	
Coatings	–$9.9	62%
Chemicals	–$48.1	
Producer Surplus	–$36.1	
Coatings	–$6.1	38%
Chemicals	–$30.0	
Total Social Cost	–$94.1	

Table C-7. Market Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.4, supply elasticity = 1)

	Baseline	With Reg	Change	
			Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.310%
Quantity (lb)	2,625	2,622	–3.0	–0.116%
Directly Affected: Domestic	2,625	2,622	–3.0	–0.116%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.557%
Quantity (lb)	14,390	14,360	–30.0	–0.208%
Directly Affected: Domestic	14,390	14,360	–30.0	–0.208%

Table C-8. Industry-Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.4, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,762	$7.3	0.194%
Costs	$1,877	$1,889	$11.6	0.620%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,873	–$4.4	–0.232%
Operating Profit	$1,877	$1,873	–$4.4	–0.232%
Chemicals				
Revenue	$10,217	$10,252	$35.6	0.348%
Costs	$5,108	$5,165	$56.8	1.112%
Control	NA	$78	$78.1	NA
Production	$5,108	$5,087	–$21.3	–0.416%
Operating Profit	$5,108	$5,087	–$21.3	–0.416%
Total				
Revenue	$13,971	$14,014	$42.8	0.307%
Costs	$6,985	$7,054	$68.4	0.980%
Control	NA	$94	$94.1	NA
Production	$6,985	$6,960	–$25.6	–0.367%
Operating Profit	$6,985	$6,960	–$25.6	–0.367%

Table C-9. Distribution of Social Costs ($) (continuous product = 0.5 * batch production, demand elasticity = –0.4, supply elasticity = 1)

Consumer Surplus	–$68.5	
Coatings	–$11.6	73%
Chemicals	–$56.9	
Producer Surplus	–$25.6	
Coatings	–$4.4	27%
Chemicals	–$21.3	
Total Social Cost	–$94.1	

Table C-10. Market Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 1.25)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.305%
Quantity (lb)	2,625	2,621	–4.0	–0.152%
Directly Affected: Domestic	2,625	2,621	–4.0	–0.152%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.547%
Quantity (lb)	14,390	14,350	–39.2	–0.273%
Directly Affected: Domestic	14,390	14,350	–39.2	–0.273%

Table C-11. Industry-Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 1.25)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,760	$5.7	0.152%
Costs	$2,086	$2,096	$10.3	0.493%
Control	NA	$16	$16.0	NA
Production	$2,086	$2,080	–$5.7	–0.274%
Operating Profit	$1,669	$1,664	–$4.6	–0.274%
Chemicals				
Revenue	$10,217	$10,244	$27.9	0.273%
Costs	$5,676	$5,726	$50.2	0.884%
Control	NA	$78	$78.0	NA
Production	$5,676	$5,648	–$27.8	–0.490%
Operating Profit	$4,541	$4,518	–$22.3	–0.490%
Total				
Revenue	$13,971	$14,005	$33.6	0.241%
Costs	$7,762	$7,822	$60.5	0.779%
Control	NA	$94	$94.0	NA
Production	$7,762	$7,728	–$33.5	–0.432%
Operating Profit	$6,209	$6,182	–$26.8	–0.432%

Table C-12. Distribution of Social Costs ($) (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 1.25)

Consumer Surplus	–67.3	
Coatings	–$11.4	72%
Chemicals	–$55.6	
Producer Surplus	–$26.8	
Coatings	–$4.6	28%
Chemicals	–$22.3	
Total Social Cost	–$94.1	

Table C-13. Market Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 0.75)

	Baseline	With Reg	Change: Absolute	Change: Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.256%
Quantity (lb)	2,625	2,622	–3.4	–0.128%
Directly Affected: Domestic	2,625	2,622	–3.4	–0.128%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.003	0.460%
Quantity (lb)	14,390	14,357	–33.0	–0.229%
Directly Affected: Domestic	14,390	14,357	–33.0	–0.229%

Table C-14. Industry-Level Impacts (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 0.75)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,759	$4.8	0.128%
Costs	$1,609	$1,620	$11.2	0.696%
Control	NA	$16	$16.0	NA
Production	$1,609	$1,604	–$4.8	–0.298%
Operating Profit	$2,145	$2,139	–$6.4	–0.298%
Chemicals				
Revenue	$10,217	$10,240	$23.5	0.230%
Costs	$4,379	$4,433	$54.7	1.248%
Control	NA	$78	$78.0	NA
Production	$4,379	$4,355	–$23.4	–0.534%
Operating Profit	$5,838	$5,807	–$31.2	–0.534%
Total				
Revenue	$13,971	$13,999	$28.3	0.202%
Costs	$5,988	$6,053	$65.9	1.100%
Control	NA	$94	$94.0	NA
Production	$5,988	$5,959	–$28.2	–0.471%
Operating Profit	$7,983	$7,946	–$37.6	–0.471%

Table C-15. Distribution of Social Costs ($) (continuous product = 0.5 * batch production, demand elasticity = –0.5, supply elasticity = 0.75)

Consumer Surplus	–$56.6	
Coatings	–$9.6	60%
Chemicals	–$46.9	
Producer Surplus	–$37.6	
Coatings	–$6.4	40%
Chemicals	–$31.2	
Total Social Cost	–$94.1	

Table C-16. Market Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.5, supply elasticity = 1)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.285%
Quantity (lb)	2,625	2,622	–3.7	–0.142%
Directly Affected: Domestic	2,625	2,622	–3.7	–0.142%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.002	0.306%
Quantity (lb)	23,983	23,946	–36.7	–0.153%
Directly Affected: Domestic	23,983	23,946	–36.7	–0.153%

Table C-17. Industry-Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.5, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,760	$5.3	0.142%
Costs	$1,877	$1,888	$10.7	0.568%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,872	–$5.3	–0.284%
Operating Profit	$1,877	$1,872	–$5.3	–0.284%
Chemicals				
Revenue	$17,028	$17,054	$26.1	0.153%
Costs	$8,514	$8,566	$52.1	0.612%
Control	NA	$78	$78.1	NA
Production	$8,514	$8,488	–$26.0	–0.306%
Operating Profit	$8,514	$8,488	–$26.0	–0.306%
Total				
Revenue	$20,782	$20,813	$31.4	0.151%
Costs	$10,391	$10,454	$62.7	0.604%
Control	NA	$94	$94.1	NA
Production	$10,391	$10,360	–$31.3	–0.302%
Operating Profit	$10,391	$10,360	–$31.3	–0.302%

Table C-18. Distribution of Social Costs ($) (continuous product = 1.5 * batch production, demand elasticity = –0.5, supply elasticity = 1)

Consumer Surplus	–$62.8	
Coatings	–$10.7	67%
Chemicals	–$52.1	
Producer Surplus	–$31.3	
Coatings	–$5.3	33%
Chemicals	–$26.0	
Total Social Cost	–$94.2	

Table C-19. Market Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.6, supply elasticity = 1)

	Baseline	With Reg	Change	
			Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.263%
Quantity (lb)	2,625	2,621	–4.3	–0.164%
Directly Affected: Domestic	2,625	2,621	–4.3	–0.164%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.002	0.283%
Quantity (lb)	23,983	23,940	–42.3	–0.176%
Directly Affected: Domestic	23,983	23,940	–42.3	–0.176%

Table C-20. Industry-Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.6, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,758	$3.7	0.098%
Costs	$1,877	$1,887	$9.8	0.524%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,871	–$6.1	–0.327%
Operating Profit	$1,877	$1,871	–$6.1	–0.327%
Chemicals				
Revenue	$17,028	$17,046	$18.1	0.106%
Costs	$8,514	$8,562	$48.1	0.565%
Control	NA	$78	$78.1	NA
Production	$8,514	$8,484	–$30.0	–0.353%
Operating Profit	$8,514	$8,484	–$30.0	–0.353%
Total				
Revenue	$20,782	$20,804	$21.7	0.105%
Costs	$10,391	$10,449	$57.9	0.557%
Control	NA	$94	$94.1	NA
Production	$10,391	$10,355	–$36.2	–0.348%
Operating Profit	$10,391	$10,355	–$36.2	–0.348%

Table C-21. Distribution of Social Costs ($) (continuous product = 1.5 * batch production, demand elasticity = –0.6, supply elasticity = 1)

Consumer Surplus	–58.0	
Coatings	–$9.9	62%
Chemicals	–$48.1	
Producer Surplus	–$36.1	
Coatings	–$6.1	38%
Chemicals	–$30.0	
Total Social Cost	–$94.1	

Table C-22. Market Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.4, supply elasticity = 1)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.310%
Quantity (lb)	2,625	2,622	–3.0	–0.116%
Directly Affected: Domestic	2,625	2,622	–3.0	–0.116%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.002	0.334%
Quantity (lb)	23,983	23,953	–30.0	–0.125%
Directly Affected: Domestic	23,983	23,953	–30.0	–0.125%

Table C-23. Industry-Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.4, supply elasticity = 1)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,762	$7.3	0.194%
Costs	$1,877	$1,889	$11.6	0.620%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,873	–$4.4	–0.232%
Operating Profit	$1,877	$1,873	–$4.4	–0.232%
Chemicals				
Revenue	$17,028	$17,063	$35.6	0.209%
Costs	$8,514	$8,571	$56.8	0.668
Control	NA	$78	$78.1	NA
Production	$8,514	$8,493	–$21.3	–0.250%
Operating Profit	$8,514	$8,493	–$21.3	–0.250%
Total				
Revenue	$20,782	$20,825	$42.8	0.206%
Costs	$10,391	$10,459	$68.5	0.659%
Control	NA	$94	$94.1	NA
Production	$10,391	$10,365	–$25.6	–0.247%
Operating Profit	$10,391	$10,365	–$25.6	–0.247%

Table C-24. Distribution of Social Costs ($) (continuous product = 1.5 * batch production, demand elasticity = –0.4, supply elasticity = 1)

Consumer Surplus	–68.5	
Coatings	–$11.6	73%
Chemicals	–$56.9	
Producer Surplus	–$25.6	
Coatings	–$4.4	27%
Chemicals	–$21.3	
Total Social Cost	–$94.2	

Table C-25. Market Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.5, supply elasticity = 1.25)

	Baseline	With Reg	Change	
			Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.305%
Quantity (lb)	2,625	2,621	–4.0	–0.152%
Directly Affected: Domestic	2,625	2,621	–4.0	–0.152%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.002	0.328%
Quantity (lb)	23,983	23,943	–39.3	–0.164%
Directly Affected: Domestic	23,983	23,943	–39.3	–0.164%

Table C-26. Industry-Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –0.5, supply elasticity = 1.25)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,760	$5.7	0.152%
Costs	$2,086	$2,096	$10.3	0.493%
Control	NA	$16	$16.0	NA
Production	$2,086	$2,080	–$5.7	–0.274%
Operating Profit	$1,669	$1,664	–$4.6	–0.274%
Chemicals				
Revenue	$17,028	$17,056	$27.9	0.164%
Costs	$9,460	$9,510	$50.2	0.531%
Control	NA	$78	$78.1	NA
Production	$9,460	$9,432	–$27.9	–0.295%
Operating Profit	$7,568	$7,546	–$22.3	–0.295%
Total				
Revenue	$20,782	$20,816	$33.6	0.162%
Costs	$11,546	$11,606	$60.5	0.524%
Control	NA	$94	$94.1	NA
Production	$11,546	$11,512	–$33.6	–0.291%
Operating Profit	$9,236	$9,210	–$26.9	–0.291%

Table C-27. Distribution of Social Costs ($) (continuous product = 1.5 * batch production, demand elasticity = –0.5, supply elasticity = 1.25)

Consumer Surplus	–$67.3	
Coatings	–$11.4	71%
Chemicals	–$55.9	
Producer Surplus	–$26.9	
Coatings	–$4.6	29%
Chemicals	–$22.3	
Total Social Cost	–$94.2	

Table C-28. Market Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –1.5, supply elasticity = 0.75)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.256%
Quantity (lb)	2,625	2,622	–3.4	–0.128%
Directly Affected: Domestic	2,625	2,622	–3.4	–0.128%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.002	0.276%
Quantity (lb)	23,983	23,949	–33.0	–0.138%
Directly Affected: Domestic	23,983	23,949	–33.0	–0.138%

Table C-29. Industry-Level Impacts (continuous product = 1.5 * batch production, demand elasticity = –1.5, supply elasticity = 0.75)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,759	$4.8	0.128%
Costs	$1,609	$1,620	$11.2	0.696%
Control	NA	$16	$16.0	NA
Production	$1,609	$1,604	–$4.8	–0.298%
Operating Profit	$2,145	$2,139	–$6.4	–0.298%
Chemicals				
Revenue	$17,028	$17,051	$23.5	0.138%
Costs	$7,298	$7,352	$54.7	0.749%
Control	NA	$78	$78.1	NA
Production	$7,298	$7,274	–$23.4	–0.321%
Operating Profit	$9,730	$9,699	–$31.2	–0.321%
Total				
Revenue	$20,782	$20,810	$28.3	0.136%
Costs	$8,907	$8,972	$65.9	0.740%
Control	NA	$94	$94.1	NA
Production	$8,907	$8,878	–$28.2	–0.317%
Operating Profit	$11,875	$11,838	–$37.6	–0.317%

Table C-30. Distribution of Social Costs ($) (continuous product = 0.5 * batch production, demand elasticity = –1.5, supply elasticity = 0.75)

Consumer Surplus	–$56.6	
Coatings	–$9.6	60%
Chemicals	–$46.9	
Producer Surplus	–$37.6	
Coatings	–$6.4	40%
Chemicals	–$31.2	
Total Social Cost	–$94.2	

Appendix D

Model Results, Including Batch Chemical Producers Only

EPA has no data on the quantity of MON organic chemicals produced using continuous production processes. In the main body of the report, EPA has assumed that the quantity of MON organic chemicals produced using continuous production processes is exactly equal to that produced using batch processes.

Because EPA is uncertain about the quantity of organic chemicals produced using continuous processes but has detailed data for organic chemicals produced using batch processes, this appendix presents model results for batch chemical producers only, varying the elasticities of demand and supply as described in Appendix B.

Table D-1. Market Level Impacts (does not include costs for continuous process facilities; supply elasticity = 1, demand elasticity = –0.5)

	Baseline	With Reg	Change	
			Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.285%
Quantity (lb)	2,625	2,622	–3.7	–0.142%
Directly Affected: Domestic	2,625	2,622	–3.7	–0.142%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.548%
Quantity (lb)	9,593	9,567	–26.2	–0.273%
Directly Affected: Domestic	9,593	9,567	–26.6	–0.273%

Table D-2. Industry-Level Impacts (does not include costs for continuous process facilities; supply elasticity = 1, demand elasticity = –0.5)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,760	$5.3	0.142%
Costs	$1,877	$1,888	$10.7	0.568%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,872	–$5.3	–0.284%
Operating Profit	$1,877	$1,872	–$5.3	–0.284%
Chemicals				
Revenue	$6,811	$6,830	$18.6	0.274%
Costs	$3,406	$3,443	$37.2	1.093%
Control	NA	$56	$55.8	NA
Production	$3,406	$3,387	–$18.6	–0.545%
Operating Profit	$3,406	$3,387	–$18.6	–0.545%
Total				
Revenue	$10,565	$10,589	$24.0	0.227%
Costs	$5,283	$5,331	$47.9	0.906%
Control	NA	$72	$71.8	NA
Production	$5,283	$5,259	–$23.9	–0.452%
Operating Profit	$5,283	$5,259	–$23.9	–0.452%

Table D-3. Distribution of Social Costs ($) (does not include costs for continuous process facilities; supply elasticity = 1, demand elasticity = –0.5)

Consumer Surplus	–$48.0	
Coatings	–$10.7	67%
Chemicals	–$37.3	
Producer Surplus	–$23.9	
Coatings	–$5.3	33%
Chemicals	–$18.6	
Total Social Cost	–$71.9	

Table D-4. Market Level Impacts (continuous costs not included; demand elasticity = (1.25 * –0.5)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.263%
Quantity (lb)	2,625	2,621	–4.3	–0.164%
Directly Affected: Domestic	2,625	2,621	–4.3	–0.164%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.506%
Quantity (lb)	9,593	9,563	–30.2	–0.315%
Directly Affected: Domestic	9,593	9,563	–30.2	–0.315%

Table D-5. Industry-Level Impacts (continuous costs not included; demand elasticity = (1.25 * –0.5)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,758	$3.7	0.098%
Costs	$1,877	$1,887	$9.8	0.524%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,871	–$6.1	–0.327%
Operating Profit	$1,877	$1,871	–$6.1	–0.327%
Chemicals				
Revenue	$6,811	$6,824	$12.9	0.189%
Costs	$3,406	$3,440	$34.3	1.008%
Control	NA	$56	$55.8	NA
Production	$3,406	$3,384	–$21.4	–0.629%
Operating Profit	$3,406	$3,384	–$21.4	–0.629%
Total				
Revenue	$10,565	$10,582	$16.6	0.157%
Costs	$5,283	$5,327	$44.2	0.836%
Control	NA	$72	$71.7	NA
Production	$5,283	$5,255	–$27.6	–0.522%
Operating Profit	$5,283	$5,255	–$27.6	–0.522%

Table D-6. Distribution of Social Costs ($) (continuous costs not included; demand elasticity = (1.25 * –0.5)

Consumer Surplus	–$44.3	
Coatings	–$9.9	62%
Chemicals	–$34.4	
Producer Surplus	–$27.6	
Coatings	–$6.1	38%
Chemicals	–$21.4	
Total Social Cost	–$71.8	

Table D-7. Market Level Impacts (continuous costs not included; demand elasticity = –0.4)

	Baseline	With Reg	Change	
			Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.310%
Quantity (lb)	2,625	2,622	–3.0	–0.116%
Directly Affected: Domestic	2,625	2,622	–3.0	–0.116%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.598%
Quantity (lb)	9,593	9,572	–21.4	–0.223%
Directly Affected: Domestic	9,593	9,572	–21.4	–0.223%

Table D-8. Industry-Level Impacts (continuous costs not included; demand elasticity = –0.4)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,762	$7.3	0.194%
Costs	$1,877	$1,889	$11.6	0.620%
Control	NA	$16	$16.0	NA
Production	$1,877	$1,873	–$4.4	–0.232%
Operating Profit	$1,877	$1,873	–$4.4	–0.232%
Chemicals				
Revenue	$6,811	$6,836	$25.4	0.373%
Costs	$3,406	$3,446	$40.6	1.193%
Control	NA	$56	$55.8	NA
Production	$3,406	$3,390	–$15.2	–0.446%
Operating Profit	$3,406	$3,390	–$15.2	–0.446%
Total				
Revenue	$10,565	$10,598	$32.7	0.310%
Costs	$5,283	$5,335	$52.3	0.989%
Control	NA	$72	$71.8	NA
Production	$5,283	$5,263	–$19.5	–0.370%
Operating Profit	$5,283	$5,263	–$19.5	–0.370%

Table D-9. Distribution of Social Costs ($) (continuous costs not included; demand elasticity = –0.4)

Consumer Surplus	–$52.3	
Coatings	–$11.6	73%
Chemicals	–$40.7	
Producer Surplus	–$19.5	
Coatings	–$4.4	27%
Chemicals	–$15.2	
Total Social Cost	–$71.9	

Table D-10. Market Level Impacts (continuous costs not included; supply elasticity = 1.25)

			Change	
	Baseline	**With Reg**	**Absolute**	**Relative**
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.305%
Quantity (lb)	2,625	2,621	–4.0	–0.152%
Directly Affected: Domestic	2,625	2,621	–4.0	–0.152%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.587%
Quantity (lb)	9,593	9,565	–28.0	–0.292%
Directly Affected: Domestic	9,593	9,565	–28.0	–0.292%

Table D-11. Industry-Level Impacts (continuous costs not included; supply elasticity = 1.25)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,760	$5.7	0.152%
Costs	$2,086	$2,096	$10.3	0.493%
Control	NA	$16	$16.0	NA
Production	$2,086	$2,080	–$5.7	–0.274%
Operating Profit	$1,669	$1,664	–$4.6	–0.274%
Chemicals				
Revenue	$6,811	$6,831	$20.0	0.293%
Costs	$3,784	$3,820	$35.9	0.948%
Control	NA	$56	$55.8	NA
Production	$3,784	$3,764	–$19.9	–0.526%
Operating Profit	$3,027	$3,011	–$15.9	–0.526%
Total				
Revenue	$10,565	$10,591	$25.7	0.243%
Costs	$5,870	$5,916	$46.2	0.786%
Control	NA	$72	$71.8	NA
Production	$5,870	$5,844	–$25.6	–0.436%
Operating Profit	$4,696	$4,675	–$20.5	–0.436%

Table D-12. Distribution of Social Costs ($) (continuous costs not included; supply elasticity = 1.25)

Consumer Surplus	–$51.4	
Coatings	–$11.4	72%
Chemicals	–$39.9	
Producer Surplus	–$20.5	
Coatings	–$4.6	28%
Chemicals	–$15.9	
Total Social Cost	–$71.8	

Table D-13. Market Level Impacts (continuous costs not included; supply elasticity = 0.75)

	Baseline	With Reg	Change	
			Absolute	Relative
Coatings				
Price ($/lb)	$1.43	$1.43	$0.004	0.256%
Quantity (lb)	2,625	2,622	–3.4	–0.128%
Directly Affected: Domestic	2,625	2,622	–3.4	–0.128%
Chemicals				
Price ($/lb)	$0.71	$0.71	$0.004	0.494%
Quantity (lb)	9,593	9,569	–23.6	–0.246%
Directly Affected: Domestic	9,593	9,569	–23.6	–0.246%

Table D-14. Industry-Level Impacts (continuous costs not included; supply elasticity = 0.75)

	Baseline	With Reg	Absolute	Relative
Coatings				
Revenue	$3,754	$3,759	$4.8	0.128%
Costs	$1,609	$1,620	$11.2	0.696%
Control	NA	$16	$16.0	NA
Production	$1,609	$1,604	–$4.8	–0.298%
Operating Profit	$2,145	$2,139	–$6.4	–0.298%
Chemicals				
Revenue	$6,811	$6,828	$16.8	0.246%
Costs	$2,919	$2,958	$39.1	1.339%
Control	NA	$56	$55.8	NA
Production	$2,919	$2,902	–$16.7	–0.573%
Operating Profit	$3,892	$3,870	–$22.3	–0.573%
Total				
Revenue	$10,565	$10,587	$21.6	0.204%
Costs	$4,528	$4,578	$50.3	1.110%
Control	NA	$72	$71.8	NA
Production	$4,528	$4,507	–$21.5	–0.475%
Operating Profit	$6,037	$6,009	–$28.7	–0.475%

Table D-15. Distribution of Social Costs ($) (continuous costs not included; supply elasticity = 0.75)

Consumer Surplus	–$43.2	
Coatings	–$9.6	60%
Chemicals	–$33.6	
Producer Surplus	–$28.7	
Coatings	–$6.4	40%
Chemicals	–$22.3	
Total Social Cost	–$71.9	

Appendix E

Small Business Screening Sensitivity Analyses

The small business screening analysis presented in Section 5 is based on two premises that, when dropped, may alter the results of the analysis somewhat. First, consider the assumption that the compliance costs applicable to continuous production processes were distributed evenly among 140 chemical manufacturing facilities. If small businesses own small facilities, their compliance cost burden is likely to be overestimated in the analysis presented in Section 5. Section E.1 of this appendix presents a screening analysis based only on the compliance costs borne by facilities as a result of their batch production processes. In addition to presenting the effects of the regulation on the batch producers of chemicals alone, this section presents a sensitivity analysis in which the effects of the coating and chemical regulations are combined. Because they are likely to own multiple facilities, large firms are more likely than small firms to be affected by both the coatings and other miscellaneous organic chemicals regulations. The combined impact of both regulations, then, may result in no difference between the impacts of the MON regulation on large and small firms. The combined analysis, presented in Section E.2 of this appendix, leads to the same basic conclusion as the analysis in the main body of this report: large businesses will experience slightly milder effects from the regulation than small businesses.

E.1 Impact of the Regulation of the Manufacture of Miscellaneous Organic Chemicals using Batch Production Processes

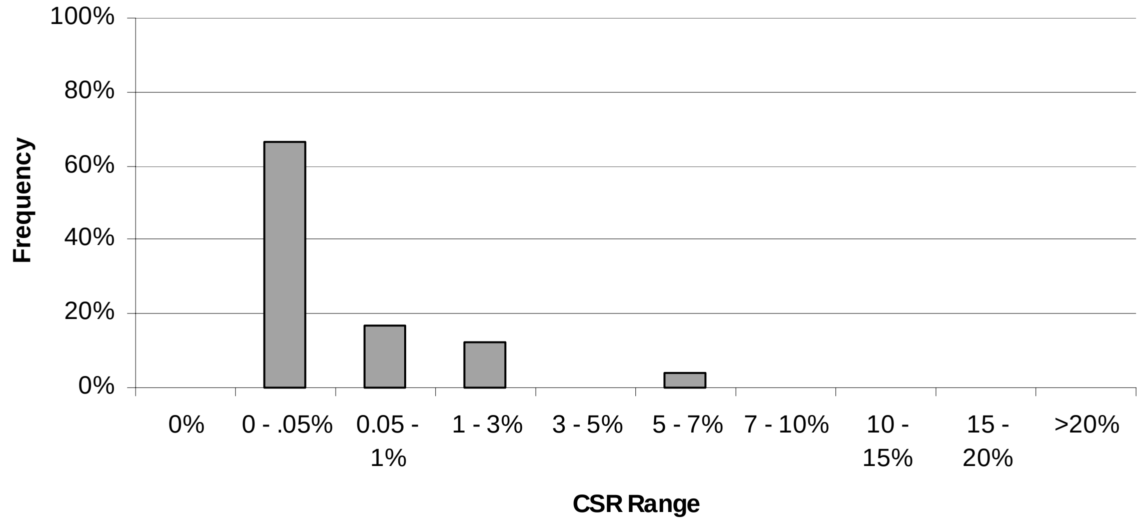
Table E-1 reports the compliance costs of the regulation of batch production processes at facilities that manufacture miscellaneous organic chemicals. The table also shows the number of companies affected at the 1 percent and 3 percent levels and summary statistics of the CSRs of small companies. Figures E-1(a) and (b) illustrate the distribution of these ratios across small and large companies with sales data. There is no definite difference in the relative effects of the regulation on small and large businesses when the effects of the compliance costs applicable to continuous production processes are removed.

The aggregate compliance costs of the regulation of batch production of miscellaneous organic chemicals total $4.7 million for small businesses (see Table E-1). RTI obtained sales data for 24 of the 27 small companies that own affected facilities, or 89 percent. For small companies, the annual compliance costs for small businesses range from 0 to 6.23 percent of sales. The average (median) compliance CSR is 0.74 (0.22) percent for the identified small businesses with sales data. As shown, three small companies are affected at the 1 percent to 3 percent level and one small company is affected at the 3 percent level. In

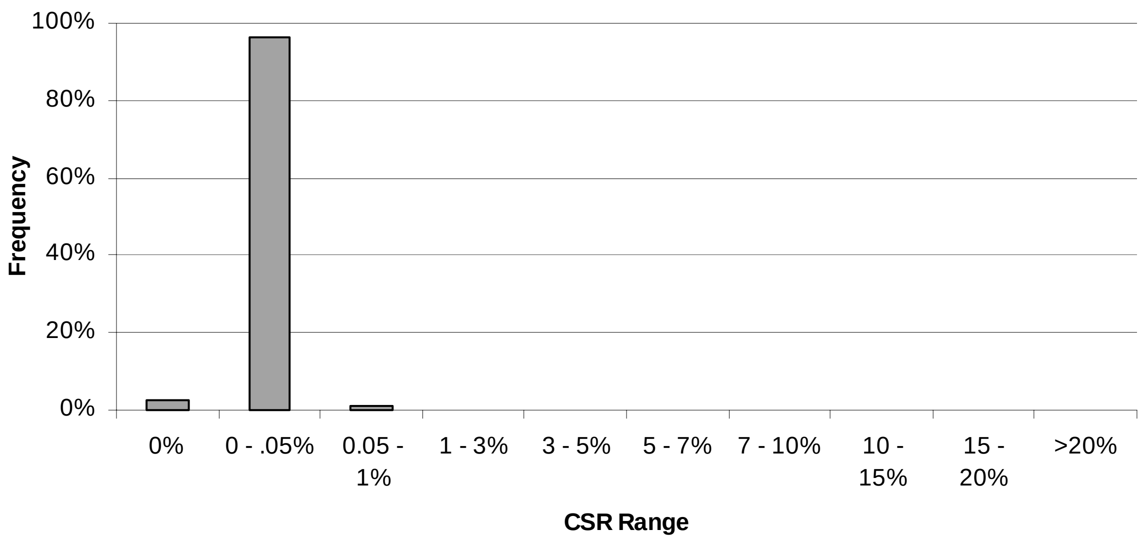
Table E-1. Summary Statistics for SBREFA Screening Analysis: Impact of the Regulation of the Batch Production of Miscellaneous Organic Chemicals other than Coatings

	Small		Large		All Companies	
Total number of companies	27		85		112	
Annual compliance costs ($\$10^6$/yr)	\$4.7		\$51.3		\$56	
	Number	Share	Number	Share	Number	Share
Companies with sales data	24		85		109	
Compliance costs are <1% of sales	20	83%	85	100%	105	96%
Compliance costs are ≥1 to 3% of sales	3	13%	0	0%	3	3%
Compliance costs are ≥3% of sales	1	4%	0	0%	1	1%
Compliance cost-to-sales ratios						
Average	0.74%		0.04%		0.19%	
Median	0.22%		0.01%		0.02%	
Maximum	6.23%		0.51%		6.23%	
Minimum	0.00%		0.00%		0.00%	

Note: Assumes no market responses (i.e., price and output adjustments) by regulated entities.



(a) Small Companies



(b) Large Companies

Figure E-1. Distribution of Cost-to-Sales Ratios

contrast, none of the 85 large companies that own facilities, affected by one or both of the regulations will find compliance costs to be greater than 1 percent of sales.

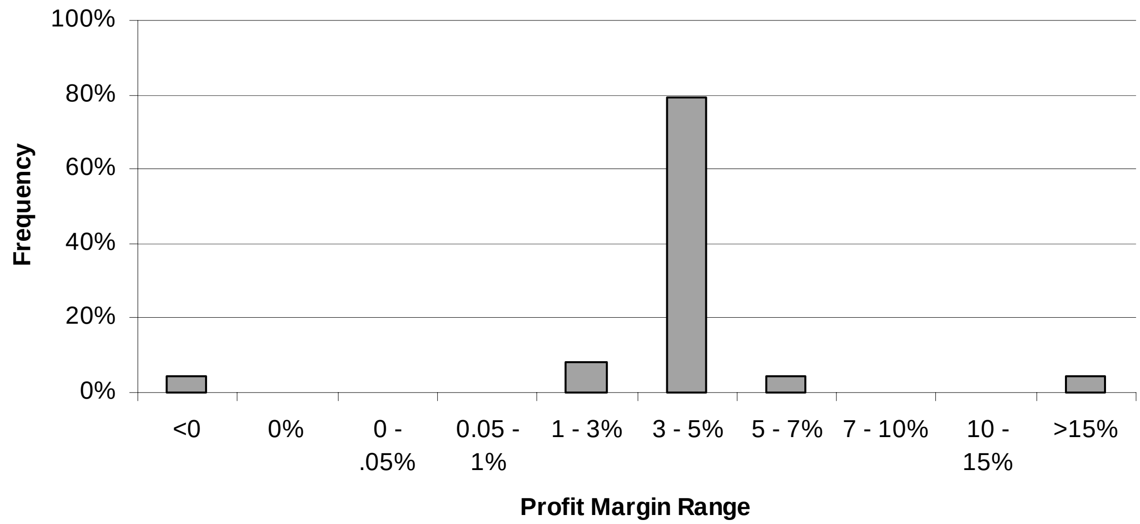
Table E-2 shows that the average and median profit margins of firms owning facilities that produce coatings will decrease more for small firms than for large firms. Figures E-2(a) and (b) show the distribution of profit margins for small and large firms under regulation.

Table E-2. Profit Margins With and Without Regulation of Batch Production of Miscellaneous Organic Chemicals

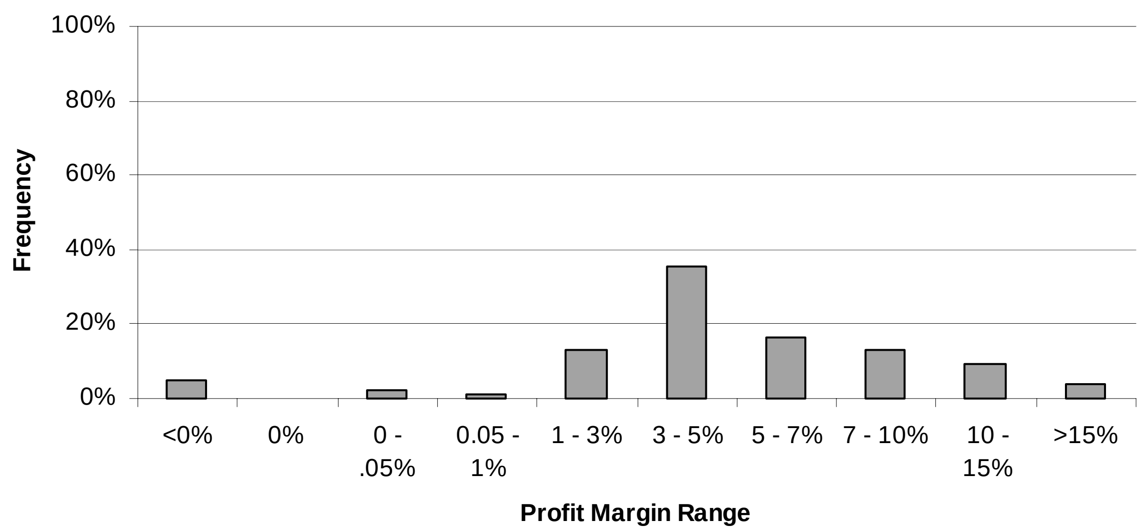
	Small Companies	Large Companies	All Companies
Profit margins without regulation			
Average	5.07%	5.34%	5.28%
Median	4.50%	4.55%	4.50%
Maximum	18.53%	18.27%	18.53%
Minimum	2.70%	–13.92%	–13.92%
Number of firms with profit margin less than zero	0	4	4
Profit margins with regulation			
Average	4.33%	5.30%	5.09%
Median	4.00%	4.55%	4.48%
Maximum	18.52%	18.21%	18.52%
Minimum	–1.13%	–13.95%	–13.95%
Number of firms with profit margin less than zero	1	4	5

E.2 Combined Impact of the Regulation of the Manufacture of Coatings and Other Miscellaneous Organic Chemicals

Table E-3 reports the combined total compliance costs of the regulation of facilities that manufacture miscellaneous organic chemicals of any kind, including those that produce coatings and those that produce other chemicals using batch and/or continuous processes. The table also shows the number of companies affected at the 1 percent and 3 percent levels and summary statistics of the CSRs of small companies. As Table E-3 shows, the combined



(a) Small Companies



(b) Large Companies

Figure E-2. Distribution of Profit Margins With Regulation

Table E-3. Summary Statistics for SBREFA Screening Analysis: Combined Impact of the Regulation of the Manufacture of Coatings and Other Miscellaneous Organic Chemicals

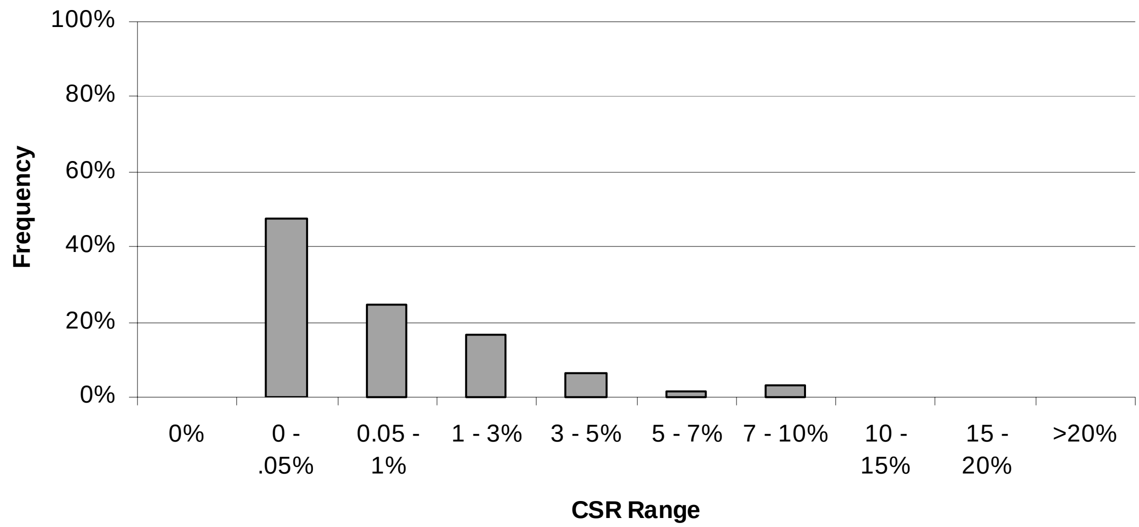
	Small		Large		All Companies	
Total number of companies	72		109		181	
Annual compliance costs ($\$10^6$/yr)	$12.6		$82.3		$94.9	
	Number	Share	Number	Share	Number	Share
Companies with sales data	65		109		174	
Compliance costs are <1% of sales	46	71%	108	99%	154	89%
Compliance costs are ≥1 to 3% of sales	12	18%	1	1%	13	7%
Compliance costs are ≥3% of sales	7	11%	0	0%	7	4%
Compliance cost-to-sales ratios						
Average	1.19%		0.07%		0.49%	
Median	0.51%		0.02%		0.06%	
Maximum	9.32%		1.45%		9.32%	
Minimum	0.00%		0.00%		0.00%	

Note: Assumes no market responses (i.e., price and output adjustments) by regulated entities.

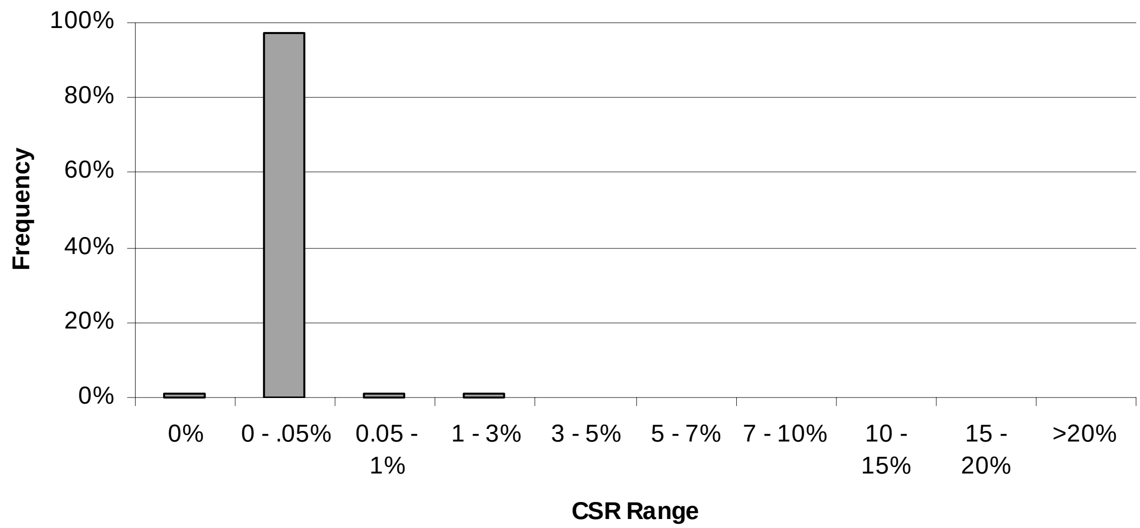
impact of both the regulation of coatings manufacturers and of other miscellaneous organic chemicals manufacturers does not appear more significant than the individual impacts of the regulation did, largely because small firms are less likely than large firms to own facilities affected by both regulations. Figures E-3(a) and (b) illustrate the distribution of these ratios across small and large companies with sales data.

The aggregate compliance costs of the regulation of facilities producing miscellaneous organic chemicals total $12.6 million for small businesses (see Table E-3). RTI obtained sales data for 65 of the 72 small companies that which own affected facilities, or 90 percent. Six small companies (8 percent) own facilities that will be affected by both regulations. For small companies, the annual compliance costs for small businesses range from 0 to 9.32 percent of sales. The average (median) compliance CSR is 1.19 (0.51) percent for the identified small businesses with sales data. As shown, 12 small companies are affected at the 1 percent to 3 percent level and seven small companies are affected at the 3 percent level. In contrast, only one of the 109 large companies that own facilities affected by one or both of the regulations will find compliance costs to be greater than 1 percent of sales.

Table E-4 shows that the average and median profit margins of firms owning facilities that produce coatings will decrease more for small firms than for large firms. Figures E-4(a) and (b) show the distribution of profit margins for small and large firms under regulation. Three small coatings businesses are projected to incur costs exceeding their estimated baseline profits. Two small businesses owning MON chemical facilities are estimated to incur costs exceeding their baseline profits.



(a) Small Companies

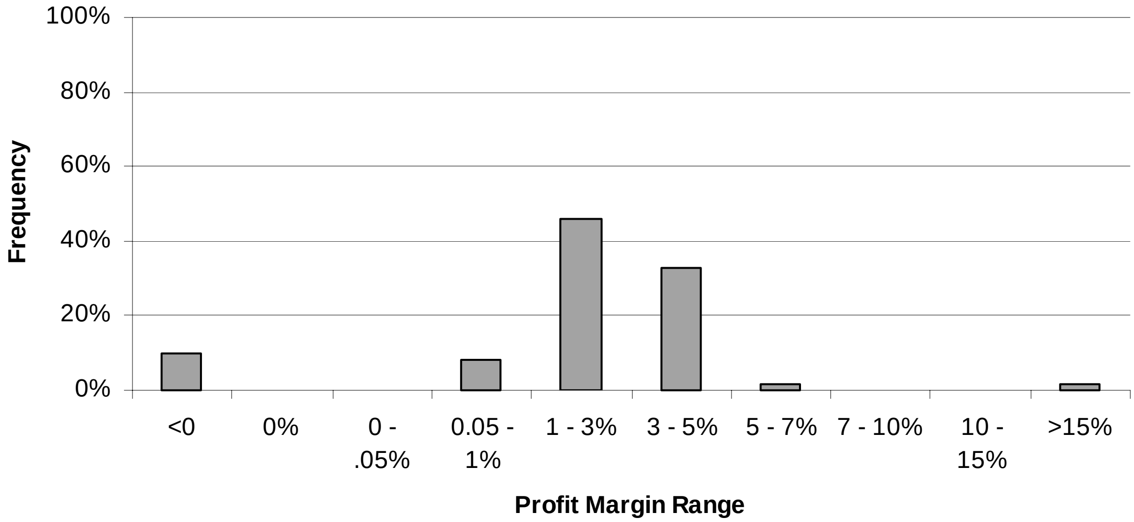


(b) Large Companies

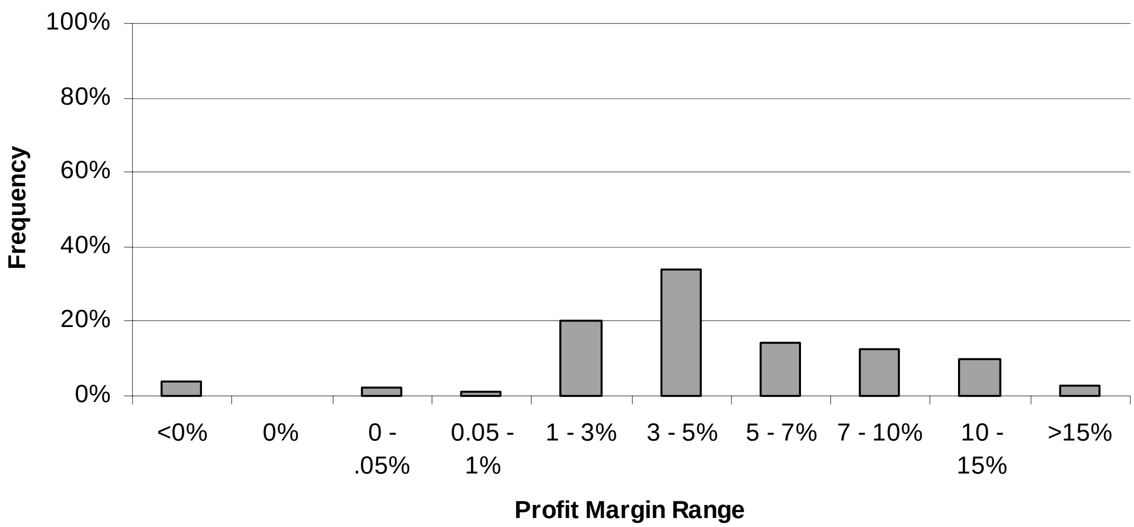
Figure E-3. Distribution of Cost-to-Sales Ratios

Table E-4. Profit Margins With and Without Combined Regulation of Coatings Manufacturers and Manufacturers of Other Miscellaneous Organic Chemicals

	Small Companies	Large Companies	All Companies
Profit margins without regulation			
Average	3.69%	5.81%	5.02%
Median	3.00%	4.50%	4.00%
Maximum	18.53%	82.74%	82.74%
Minimum	–0.24%	–13.92%	–13.92%
Number of firms with profit margin less than zero	1	4	5
Profit margins with regulation			
Average	2.50%	5.74%	4.53%
Median	2.37%	4.42%	3.69%
Maximum	18.52%	82.73%	82.73%
Minimum	–6.62%	–13.95%	–13.95%
Number of firms with profit margin less than zero	6	4	10



(a) Small Companies



(b) Large Companies

Figure E-4. Distribution of Profit Margins With Regulation

Appendix F

Industry Profile of Affected SIC Codes

The proposed MON rulemaking will affect facilities and companies producing miscellaneous organic chemical products and coatings. EPA's data do not permit clearly identifying the marketed commodities produced by these facilities or the production processes used. EPA is able to determine the general types of products produced, based on the Standard Industrial Classification (SIC) code identified for each facility. This section presents profiles of several industries as identified by their SIC codes. These SIC codes represent the industries for the majority of potentially affected facilities.

F.1 Paints and Allied Products

The paint and allied products industry is relatively small when compared to other manufacturing industries. In 1997, the sector (SIC 2851, NAICS 32551) shipped $19,221.7 million dollars worth of products. All dollar values are 1998 dollars unless otherwise indicated. This industry supplies essential products to major manufacturing and consumer industries from automobiles to home furnishings.

Typical products manufactured by the industry include paints (ready-made and paste), varnish, lacquers, enamels and shellac putties, wood filters and sealers, paint and varnish removers, paint brush cleaners, and other allied paint products.

Three market segments account for the vast majority of output: architectural coatings (SIC 28511), original equipment manufacturer (OEM) product coatings (SIC 28512), and special purpose coatings (SIC 28513). While SIC 2851 grew 16.4 percent over the period 1987 to 1995, architectural coatings grew 20.9 percent, OEM grew 18.2 percent, and special purpose coatings grew 24.0 percent in real terms. Overall, despite the recession in the early 1990s, the value of shipments increased 25.8 percent from 1987 to $19,221.7 million in 1997 (see Table F-1).

Table F-1. Value (1998 $$10^6$) and Quantity of Shipments (10^6 gallons)

Year	SIC 2851	SIC 28511	SIC 28512	SIC 28513
Value of Shipments				
1987	15,279.7	5,106.8	4,549.9	2,557.2
1988	15,388.7	5,034.3	4,667.8	2,560.7
1989	14,966.5	4,959.4	4,624.9	2,732.7
1990	15,508.8	5,351.9	4,392.3	3,029.6
1991	15,367.5	5,283.1	4,318.0	3,138.0
1992	16,282.1	5,615.6	4,657.4	3,047.0
1993	17,382.6	6,089.1	5,192.2	3,185.5
1994	18,415.5	6,230.7	5,364.7	3,383.2
1995	18,338.2	6,174.6	5,379.7	3,171.4
1996	18,630.5	NA	NA	NA
1997	19,221.7	NA	NA	NA
Quantity of Shipments				
1987	1,183.6	527.0	340.2	145.5
1988	1,229.0	535.9	365.7	154.4
1989	1,239.7	537.5	359.9	179.0
1990	1,281.9	558.4	338.6	195.6
1991	1,226.8	537.9	320.4	179.5
1992	1,270.5	562.3	334.0	169.5
1993	1,336.5	608.1	356.6	179.0
1994	1,431.1	644.8	372.9	193.8
1995	1,408.3	621.1	376.2	195.1
1996	NA	NA	NA	NA
1997	NA	NA	NA	NA

NA = not available

Sources: U.S. Department of Commerce, Bureau of the Census. 1995f. *1992 Census of Manufactures, Industry Series: Paints and Allied Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. August 1997b. *1996 Current Industrial Reports: Paint, Varnish, and Lacquer*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999h. *1997 Economic Census*. Washington, DC: Government Printing Office.

Architectural coatings accounted for 33.7 percent of this industry's total value of shipments in 1995. Commonly referred to as house paint, the architectural coatings sector generates nearly half of the industry's revenue.

In 1995, sales of OEM constituted 29.3 percent of the industry's total value of shipments. OEM products are often custom formulated to meet applications specified by the end user. Primary users of OEM paints are automobile, appliance, equipment manufacturing, and furniture industries.

Special purpose coatings shipments amounted to 17.3 percent of the 1995 industry receipts. While similar to architectural coatings in that this sector could be classified as stock or shelf goods, the special purpose coatings sector formulates its product for specific applications and/or environmental conditions and typically sells directly to the end user. The primary markets for its products are automotive, machine refinishing, industry maintenance, bridge and traffic markings, and marine.

F.1.1 Supply Side of the Industry

F.1.1.1 Production Processes

Paints primarily comprise pigments, resins, and solvents. The industry purchases the majority of its inputs from other manufacturers in the chemical industry (SIC 28). At one time, lead was a primary component of paint; however, its use was banned in the 1980s because of concerns over lead poisoning from paint chips. Most paints comprise four basic groups of chemical raw materials: binders and resins, pigments and extenders, solvents, and additives. When a paint is applied to a surface, the solvents begin to evaporate while the binder, pigments, and additives remain on the surface and harden to form a solid film. The chemical and physical properties of paints are directly related to the choice and concentration of raw materials determined during the production process.

The particular raw material ingredients used in paints are chosen not only for their appearance and performance attributes, but also for their compatibility with each other and the ease with which they are mixed together to create a stable and homogenous paint product without undergoing significant chemical reactions during the process. Although some chemical reactions occur during the mixing process, the manufacturing process results in a near 100 percent yield. No reactions take place that produce unwanted chemical by-products. The manufacturing of paints is concerned with the proper blending and mixing of raw materials to ensure that the ingredients are evenly dispersed in the finished paint.

Paints are divided into two categories: water- and solvent-based paints and powder paint.

Water- and Solvent-Based Paints Production. The manufacturing process for both water- and solvent-based paints begins with weighing-out and premixing batch ingredients. Next, the pigment particles are wet with resins and then dispersed in the paint system. For water-based paints, surfactants must be added to prevent flocculation. This process may take from 10 minutes to 48 hours to complete.

After the pigment has dispersed through the resin, the paste is thinned with a solvent (such as toluene or xylene) or more resin. After a second run through the system, the thinned paste is transferred to a let-down tank to receive more additives. The primary difference between solvent- and water-based paints is that solvent-based paints receive the binder during the dispersion process. Water-based paints receive the binder while in the let-down tank. After leaving the let-down tank, the paint undergoes further thinning and filtration before flowing into the canning apparatus.

When the manufacturer decides to change the color or content of the product, the tanks and equipment are washed with solvents to remove residue and any buildup that may adversely affect the quality of the paint.

Powder-Based Paints. To manufacture powdered paints, the dry components of powder-based paints (40 to 50 percent binder, 40 to 50 percent pigments and filler, and 1 to 2 percent additives) are transferred from holding areas, weighed-out, and then placed into a mixer. After being mixed, the material is then transferred to a double screw extruder where it is processed at 100°C to 120°C. The components exit the machine in sheet form. The sheet is allowed to cool before being chipped and eventually pulverized and sieved into a fine powder with a mean size of 50 µm. The powder is then bagged for shipment.

The most significant development in the modern paint industry is the development of waterborne paints, or latex paint. Prior to the 1950s, the majority of paint sold was solvent- or oil-based. By the 1990s, waterborne paints accounted for over 75 percent of gallonage. Other industry trends include high solids that contain more resins and pigments than solvents, and the aforementioned powder paints that are sprayed on dry and electrically adhere to the surface, almost eliminating the need for organic solvents.

F.1.1.2 Major By-products and Co-products

The chemical by-products associated with manufacturing paints and allied products are few because the manufacturing process does not involve chemical reactions. In those instances where a minor chemical reaction does occur, chiefly during the mixing stage, the resultant reaction is not significant enough to reduce the yield. However, chemical emissions do result from the transportation and handling of the product.

Half of the chemical by-products are generated during the manufacturing process when the ingredients used to create the product change. The tanks are cleaned with solvents that produce volatile organic compounds (VOCs) as they evaporate. Any solvents gathered after the cleansing process is complete are distilled onsite. Wastewater is filtered to remove solids before being discharged to a publicly owned treatment works (POTW) as nonhazardous waste. Still bottoms and filters are collected and dried before being sent offsite for treatment and disposal as nonhazardous waste.

The remaining emissions associated with paints and allied products result during the application process. After the product is applied, the solvents and other ingredients evaporate to leave behind the protective or decorative film. During evaporation, VOCs and hazardous air pollutants (HAPs) are emitted, constituting the second half of chemical by-products associated with this industry.

Co-products of paints and allied products are caulking and spackling compounds.

F.1.1.3 Types of Output

The various products produced by the paint and allied products industry can be divided and described as follows:

- Architectural coatings: Protective and decorative coatings applied onsite to the interior or exterior surfaces of industrial, commercial, institutional, or residential buildings for ordinary use and exposure.
  - Clear finishes and spar varnishes: Transparent protective and/or decorative films, including urethane coatings, natural varnishes, and shellac varnishes.
  - Eggshell finish: Low sheen (semimatte) surface that exhibits its surface reflectance (gloss) similar to that of an eggshell, between flat and semigloss.
  - Enamels: Normally high gloss, but increasingly less glossy, these topcoats are used for their ability to form a smooth surface.

- Primer: A paint designed to provide adequate adhesion to new surfaces and to meet special requirements such as absorption and/or corrosion control.
- Stains: Transparent and semitransparent solutions or suspensions of coloring matter in a vehicle designed to color a surface without hiding it or to color a material into which it was incorporated.
- Solvent: A volatile nonaqueous liquid used to dissolve or disperse the coating constituents. This liquid evaporates during the drying process and does not become part of the dried coating.
- Lacquers: Coatings composed of synthetic thermoplastic materials dissolved in organic solvent and dried primarily by solvent evaporation. Typical lacquers include those based on nitrocellulose and other cellulose derivations, vinyl resins, and acrylic resins.
- Undercoat: A coat of paint applied on a new wood, over a primer or previous coat of paint, to improve the seal and to serve as a base for a topcoat.
- Exterior coatings: Coatings that are expected to possess reasonable durability when exposed to natural weathering.

• OEM coatings: Coatings designed specifically for an OEM to meet application and product requirements to be applied during the manufacturing process.

  - Powder coatings: 100 percent solid coatings applied as dry powders and subsequently formed into a film with heat.
  - Electrical insulating coatings: Often used in conjunction with mica and fabrics, these coatings provide insulation for electrical equipment and have a high resistance to electrical conduction.

• Special purpose coatings: These coatings differ from architectural coatings in that they are formulated for special applications and/or environmental conditions such as extreme temperatures, chemicals, and fumes.

  - Industrial new construction and maintenance paints: High-performance coatings formulated to withstand extreme uses, such as environmental elements, abrasion, fungi, chemicals, corrosion, electrical, or solvent exposure. They are also used to protect public utilities' facilities, railroads, roads and highways, and industrial interiors and exteriors.
  - Marine paints including ships and offshore facilities: Paints and coatings designed to withstand water immersion and exposure to marine atmosphere.

- Traffic paints: Marking paints formulated to withstand the wear of vehicular traffic and to be highly visible at night. These paints are used to mark traffic lanes and crosswalks, for example. Also includes shelf goods and paints designed for the highway departments.

- Refinish paints: Coatings formulated specifically to meet certain product and application requirements and sold to the refinishing trade.

- Aerosol paints: Paints packaged in an aerosol can under pressure.

F.1.1.4 Costs of Production

The inputs for paints and allied products include various resins, solvents, pigments, extenders, binders, and other additives. In constant 1998 dollars, the cost of materials rose 27 percent over the period 1987 to 1997 to $9947.9 million (see Table F-2). The higher cost of materials reflects the changing content of paint products. The use of higher solids content and environmental concerns necessitated using more expensive ingredients and using epoxies in paint. Prices for acetone, benzene, chlorine, and fiber-grade increased; however, phenol prices remained steady. The increasing cost of raw materials has been a concern for the industry.

The amount of labor employed by the industry dropped from 55,200 in 1987 to 52.7 in 1997, while the industry's payroll increased by $289.5 million (1998 dollars), indicating that the manufacturing process became increasingly mechanized and required skilled labor. The rise in the level of employment from 1995 to 1997 is expected to be temporary. Industry analysts expect the number of jobs at the manufacturing level to decrease by a minimum of 30 percent by the year 2005 (Gale Research, 1995). Energy costs averaged $118.5 million a year during the period 1987 to 1997.

F.1.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of the actual operations to the full production levels. Table F-3 presents historical trends in capacity utilization in this industry. The capacity utilization ratio for the paints and allied products industry was 66 in 1997, indicating that plants were operating below potential.

Table F-2. Inputs Used in Paints and Allied Products Industry

Year	Labor: Quantity (10^3)	Labor: Payroll (1998 $$10^6$)	Materials (1998 $$10^6$)	New Capital Investment (1998 $$10^6$)	Energy (1998 $$10^6$)
1987	55.2	1,794.2	7,830.8	330.9	122.1
1988	56.9	1,779.5	8,061.3	287.3	133.4
1989	55.0	1,761.7	7,991.1	263.9	120.6
1990	53.9	1,772.8	8,077.8	295.5	117.6
1991	51.1	1,690.6	8,014.9	275.6	117.3
1992	51.2	1,860.9	8,488.3	315.6	117.4
1993	50.2	1,839.2	8,985.9	277.9	124.7
1994	50.0	2,020.5	9,579.4	295.9	104.7
1995	52.4	2,024.7	9,796.7	426.4	109.4
1996	51.1	1,979.4	10,050.6	411.9	110.6
1997	52.7	2,083.7	9,947.9	NA	129.7

NA = Not available

Sources: U.S. Department of Commerce, Bureau of the Census. 1990f. *1988 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992a. *1990 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995f. *1992 Census of Manufactures, Industry Series: Paints and Allied Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufactures, Industry Series*. Washington, DC: Government Printing Office.

Table F-3. Capacity Utilization Ratios for SIC 2851

	1992	1993	1994	1995	1996	1997
SIC 2851	75	67	69	68	69	66

Source: U.S. Department of Commerce, Bureau of the Census. 1996. *Survey of Plant Capacity: 1994.* Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999i. *Survey of Plant Capacity: 1997.* Washington, DC: Government Printing Office.

F.1.2 Demand Side of the Industry

F.1.2.1 Product Characteristics

Modern chemistry has produced coatings that add aesthetic value and are also resistant to natural elements, or electrical conduction, or wear and tear by vehicles. The paint and allied products industry is able to formulate a coating to fulfill almost any request a client may have. In the last 20 years, the industry has made major advances in the durability and quality of coatings.

F.1.2.2 Uses and Consumers of Products

The coatings industry is essential to nine other major U.S. industries: automobiles, trucks and buses, metal cans, farm machinery and equipment, construction machinery and equipment, metal furniture and fixtures, wood furniture and fixtures, major appliances, and coil coating (high speed application of industrial coatings to continuous sheets, strips, and coils of aluminum or steel) (U.S. Department of Commerce, 1995f).

The quantity of architectural coatings demanded is directly related to the number of building sales and starts for a given period. When construction slows on residential, commercial, and industrial structures, the demand for architectural coatings slows down as well, albeit much later because of lag effects. Special purpose coatings are used in much the same way as architectural coatings, but they are formulated for special applications. Typical consumers and uses of these coatings include highway departments for road markings and bridges, ship builders for hulls, automakers for cars, and refinishers for refinishing.

OEM coatings are predominantly used during the manufacturing process of a product. Powder coatings and electrical insulating coatings are the most common products manufactured by this industrial sector. The demand for powder coats is expected to drop off due to a slowdown in durable goods production, such as home appliances (the largest market for powdered products), and a drop in conversion from liquid to powder paints. Table F-7 in Section F.1.4 presents historical data on paint production, consumption, and net exports.

F.1.2.3 Substitution Possibilities

There are few substitutions for coatings. Within the industry, the 20 percent growth of powdered paints in the 1980s quelled the demand for liquid products. Powdered paints are popular because of environmental concerns. The Clean Air Act and other regulations favored powdered paints because they do not emit any VOCs during the application process. Manufacturers of liquid coatings responded to both the regulations and the popularity of powdered coatings by increasing the amount of pigments and resins in their product and reducing the amount of solvents added. Subsequently, the demand for powdered paints decreased somewhat.

F.1.3 Organization of the Industry

F.1.3.1 Firm Characteristics

In 1997, the majority (61 percent) of facilities producing paints and allied products were small facilities with fewer than 20 employees (see Table F-4). However, these facilities contributed only 8.2 percent to the total value of shipments. As Table F-4 indicates, 907 facilities had fewer than 20 employees. These small entities are typically regional paint companies that supply local hardware stores or home repair centers.

Ownership concentration in this industry decreased from 1987 to 1992, but increased again from 1992 to 1997. In 1987, 1,121 companies operated 1,426 facilities in SIC 2851. By 1992, 1,130 companies operated 1,418 facilities in this industry. In 1997, less than 1,206 companies operated 1,486 facilities. To remain competitive, many producers have invested in research and development to develop a better product.

In 1992, the five largest coatings companies were Sherman-Williams Co. ($2,747.8 million in sales), Valspar ($683.5 million), RPM ($552.1 million), Grow Group ($416.2 million), and Standard Brands Paint ($253.0 million). These companies accounted for 31.1 percent of 1992 sales of coatings.

Table F-4. Size of Establishments and Value of Shipments for SIC 2851

Establishments With an Average of	1992 Number of Facilities	1992 Value of Shipments (1998 $\$10^6$)	1997 Number of Facilities[a]	1997 Value of Shipments[a] (1998 $\$10^6$)
1 to 4 employees	329	170.7	412	220.9
5 to 9 employees	247	368.1	245	438.9
10 to 19 employees	264	882.8	250	920.8
20 to 49 employees	306	2,378.8	296	2,495.3
50 to 99 employees	146	3,389.8	153	3,948.2
100 to 249 employees	100	5,537.4	105	6,723.8
250 to 499 employees	23	3,554.4	20	D
500 to 999 employees	1	D	3	935.0
1,000 to 2,499 employees	2	D	2	D
Total	1,418	16,282.1	1,486	19,221.7

D = undisclosed

[a] Data are estimates based on the 1997 Economic Census Report for the NAICS-coded industry 325510. Estimates based on the fact that 99.47% of the value of shipments for the NAICS-coded industry are derived from firms classified under SIC code 2851.

Sources: U.S. Department of Commerce, Bureau of the Census. 1990e. *1987 Census of Manufactures, Industry Series: Paints and Allied Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995f. *1992 Census of Manufactures, Industry Series: Paints and Allied Products*. Washington, DC: Government Printing Office.

The four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indexes (HHI) are used to assess the market structure of an industry. The CR4 for the paints and allied products industry was 29 in 1992, meaning that the top four firms accounted for only 29 percent of the industry's total sales. The CR8 for the same year was 43 (U.S. Department of Justice, 1992). This indicates that the paint and allied products market is fairly competitive. Furthermore, the HHI for paints and allied products was 305 in 1992. According to the Department of Justice's (1992) Horizontal Merger Guidelines, industries with HHIs below 1,000 are considered to be unconcentrated (i.e., more competitive).

Therefore, firms in the paints industry are more likely to be price takers. Table F-5 shows the CR4, CR8, HHI, number of companies, and number of facilities data for SIC 2851 for 1992.

Table F-5. Measures of Market Concentration by SIC: 1992

SIC	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2851	Paints and Allied Products	29	43	305	1,130	1,418

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995f. *1992 Census of Manufactures, Industry Series: Paints and Allied Products*. Washington, DC: Government Printing Office.

F.1.3.2 Geographical Distribution

Facilities involved in the coatings industry are concentrated in states with heavy involvement in manufacturing. Ohio, California, and Illinois alone accounted for 35.3 percent of the total value of shipments and 33 percent of total employment in the industry (see Table F-6).

F.1.4 Markets and Trends

F.1.4.1 Production

Table F-7 shows production and consumption trends for the period 1987 to 1994. There has been mild growth in the percentage of domestic production of paints and allied products being exported. Domestic consumption of paints and allied products increased by 10.7 percent, while domestic production increased by 14.1 percent.

Domestic. In 1996, the U.S. coatings industry produced 1,438.6 million gallons of product worth $18,630.5 million in 1998 dollars. Growth is projected to be roughly 2 to 3 percent a year through the year 2000. Markets slated for the most growth are product finishes and specialty coatings (DRI McGraw Hill, 1998).

Foreign. In 1996, foreign producers exported $1,215.6 million worth of pigments, paints, varnishes, and related materials (Standard International Trade Classification, SITC

Table F-6. Industry Statistics for the Top Ten States for SIC 2851, 1992

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees	Number of Employees
Ohio	2,014.7	79	36	6,000
California	1,912.3	189	127	5,400
Illinois	1,821.9	125	60	5,500
Michigan	1,012.9	76	49	3,200
Texas	997.6	84	55	2,500
Pennsylvania	952.4	65	34	3,000
New Jersey	827.9	91	52	2,800
Georgia	693.0	45	25	1,500
Kentucky	639.5	26	10	1,200
Maryland	504.2	20	10	1,200
USA	16,282.1	1,418	840	51,200

Sources: U.S. Department of Commerce, Bureau of the Census. 1995f. *1992 Census of Manufactures, Industry Series: Paint and Allied Products*. Washington, DC: Government Printing Office.

533) to the United States. Major exporters to the United States include NAFTA members, Germany, Japan, and Belgium.

F.1.4.2 Consumption

Domestic. Domestic consumption of foreign products is increasing, particularly since the liberalization that occurred because of NAFTA. Another significant factor affecting domestic consumption of paints is the do-it-yourself orientation of Americans. Due to this factor, the consumption of architectural coatings was expected to remain steady and possibly increase through the year 2000.

Foreign. In 1996, U.S. producers exported $2,392.2 million worth of paints, varnishes, pigments, and related materials (SITC 533). Asian, South American, and Western European markets have improved in the past 5 years, helping to stabilize the North American industry.

Table F-7. Production and Consumption Trends for SIC 2851, 1987 to 1994 (1998 $\$10^6$)

Year	Domestic Production	Domestic Consumption	Net Exports
1987	14,180.4	14,037.0	143.4
1988	14,260.2	14,031.3	228.9
1989	14,415.9	14,046.4	369.5
1990	14,894.3	14,394.3	500.0
1991	14,325.0	13,724.9	600.1
1992	14,792.2	14,172.4	619.8
1993	15,680.4	15,053.3	627.0
1994	16,183.0	15,539.6	643.4

Note: Consumption = Domestic Production - Exports + Imports

Sources: U.S. Department of Commerce, International Trade Administration. 1989. *1989 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995f. *1992 Census of Manufactures, Industry Series: Paint and Allied Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1993. *1994 U.S. Industrial Outlook.* Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

DRI McGraw Hill, Standard and Poor's and U.S. Department of Commerce, International Trade Administration. 1998. *U.S. Industry and Trade Outlook 1998.* New York: McGraw Hill.

F.2 Industrial Organic Chemicals

SICs 2865 and 2869 are divisions of the greater Industrial Organic Chemicals category, representing cyclic crudes and intermediates and industrial organic chemicals not elsewhere classified (N.E.C.), respectively. These industries correspond to North American Industry Classification System (NAICS) manufacturing codes as shown in Table F-8. These are major sectors within the U.S. chemical industry, and both industries had a combined

Table F-8. The Correspondence Between SIC Codes 2865 and 2869 and the NAICS

SIC Code	Description	NAICS Code(s)	Description
2865	Cyclic organic crudes and intermediates, and organic dyes and pigments	32511	Petrochemical manufacturing (pt)
		325132	Synthetic organic dye and pigment manufacturing
		325192	Cyclic crude and intermediate manfacturing
2869	Industrial organic chemicals, not elsewhere classified	32511	Petrochemical (pt)
		325188	All other basic inorganic chemical manufacturing
		32512	Industrial gas manufacturing
		325199	All other basic organic chemical manufacturing

pt = The NAICS industry described only partially comprises the SIC code industry shown to correspond with that NAICS industry.

Source: U.S. Department of Commerce, Bureau of the Census. 1997 NAICS and SIC Correspondence Tables. <http://www.census.gov/epcd/www/naicstab.htm>. As obtained March 6, 2000.

annual value of shipments of $83,323.4 million ($1998) in 1997 (see Table F-9). All values in this report are in 1998 dollars.

Products produced by cyclic crudes and intermediates are divided into three sectors. First, the aromatic chemical production sector produces benzene, toluene, mixed xylenes, and napthalene. The second and third sectors produce synthetic organic dyes and synthetic organic pigments, respectively. Dyes are colored substances that are fully soluble in the vehicle or medium. Pigments are colored, colorless, or flourescent finely divided solids that are usually insoluble in (and unaffected by) the vehicle or medium in which they are placed. Both provide color by absorbing or reflecting selected light rays.

The cyclic crudes and intermediates industry was affected by the early 1990s' recession. In 1989, the value of shipments reached $10,657.1 million but fell to $10,409.3

Table F-9. Value of Shipments (1998 $$10^6$)

Year	SIC 2865 Cyclic Crudes and Intermediates	SIC 2869 Industrial Organic Chemicals, N.E.C.
1987	10,657.1	50,749.4
1988	11,715.6	55,842.0
1989	11,849.3	59,742.5
1990	11,864.2	58,991.0
1991	11,483.1	57,210.9
1992	10,409.3	58,995.0
1993	11,032.7	57,788.9
1994	12,082.0	61,429.2
1995	12,692.9	64,699.1
1996	12,371.6	56,273.4
1997	12,264.0	71,059.4[a]

[a] Excludes data on two firms for which data were not available.

Sources: U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufactures, Industry Series*. Washington, DC: Government Printing Office.

million in 1992. The industry began to recover and shipped $12,264 million worth of goods in 1997, an increase of nearly 17.9 percent over 1987's value. All dollar values are in constant 1998 dollars unless otherwise indicated.

The miscellaneous industrial organic chemicals group includes establishments producing chemicals that cannot be classified in other SIC categories. Product groupings range from chemical warfare gases to synthetic perfumes and flavoring chemicals. This industry suffered from the same recessionary effects as SIC 2865, although in terms of percentages, the effects were not as significant. In 1997, its shipments were valued at $71,059.4 million, an increase of 40 percent over 1987's value.

F.2.1 Supply Side of the Industry

F.2.1.1 Production Processes

Dyes. The ingredients used in dye manufacture are varied. Both liquid and dry materials are sent to vats where they are reacted together. Vats are made out of stainless steel in the United States and Europe and sometimes of wood in developing nations. The dyes exit the vats through a system of pipes to cooling tanks. Solid dyes will either be filtered or separated by centrifuge to remove them from the liquid. Solids are pressed by plates and frames. Also at this stage, intermediates are removed and reused or manufactured. If the dyes need to be dried, air or vacuum ovens, rotary dryers, or spray dryers are used. The final stage is grinding or milling. These processes create a large amount of dust that is gathered using advanced control methods.

Pigments. Various ingredients are required to produce pigments. After choosing a hue, a manufacturer collects the necessary ingredients. The process is usually conducted in large, secured vats and involves numerous steps ranging from coupling and condensation to salt formation.

The manufacturing processes for some popular pigments are briefly described below:

- Blue 60 (Indanthrone): intermolecular condensation of F-aminoanthraquinone in the presence of a strong inorganic base and oxidizing agent.
- Red 38 (Pyrazolone Red): coupling of tetrazotized 3,3'-dichlorobenzidine with 1-phenyl-3-carbethoxy-5-pyrazolone.
- Yellow 139 (Isoindoline): reaction of 1-amino-3-iminoisoindolenine with barbituric acid.

The pigments can be heated or cooled. After the reactions, they are isolated and prepared for shipping.

Aromatic and Miscellaneous Industrial Organic Chemicals. The process by which aromatic and other industrial organic chemicals are manufactured is similar to the two processes described above. Production entails reacting (through a variety of methods) different chemical and natural raw materials together to form a product.

F.2.1.2 Major By-products and Co-products

The chemical industry produces a significant amount of waste. Even a small amount of discharge is noticeable because of the color or aroma of the emissions. For environmental and public health reasons, facilities clean their waste before discharge. Acidic and alkaline liquors are neutralized, and the waste is filtered to remove heavy materials before leaving the facility.

F.2.1.3 Types of Output

Dyes and pigments are available in a variety of forms: dry powders (both surface treated or untreated), presscakes, flushed colors (thick pastes), fluidized dispersions (pourable), resin predispersed pigments, and plastic color concentrates or master batches (granules). Pigment types include azo pigments, lakes, copper phthalocyanines, quinacridones, diaryl pyrrolopyrroles, and dioxazine.

Dyes are best classified by their chemical structure, but manufacturers prefer to classify them by their use or application method. Dye categories include reactive dyes, direct dyes, vat dyes, sulfur dyes, disperse dyes, basic dyes, solvent dyes, and acid dyes.

Aromatic chemicals include products such as benzene and toluene. Cyclic crudes include light oils and light oil products and products of medium and heavy oil such as napthalene.

Miscellaneous industrial organic chemicals comprise nine general categories of products:

- aliphitic and other acyclic organic chemicals (ethylene); acetic, chloroaceptic, adipic, formic, oxalic, and tartaric acids and their metallic salts; chloral, formaldehyde, and methylamine;
- solvents (ethyl alcohol etc.); methanol; amyl, butyl, and ethyl acetates; ethers; acetone, carbon disulfide and chlorinated solvents;
- polyhydric alcohols (synthetic glycerin, etc.);
- synthetic perfume and flavoring materials (citral, methyl, oinone, etc.);
- rubber processing chemicals, both accelerators and antioxidants (cyclic and acyclic);
- cyclic and acyclic plasticizers (phosphoric acid, etc.);

- synthetic tanning agents;
- chemical warfare gases; and
- esters, amines, etc., of polyhydric alcohols and fatty and other acids.

F.2.1.4 Costs of Production

Cyclic crudes and intermediates have long been a mature industry. Until 1996, employment varied little, holding steady at an average of 23,000 workers for the years 1987 to 1996. However, between 1996 and 1997, employment fell by 15 percent. Payroll remained around the same level during this period. It is notable that while the level of employment in the industry fell by 15 percent between 1996 and 1997, the payroll increased by almost 37 percent. The cost of materials does appear to trend upward, but only slightly. The cost of materials only increased 7.4 percent between 1987 and 1997. New capital investment averaged $724.8 million per year (see Table F-10).

Employment in miscellaneous organic chemicals, SIC 2869, averaged 97,890 for the 1987 to 1997 time period. Between 1987 and 1994, employment fell 10 percent to 89,800, after a high of 101,000 in 1991. Most jobs lost were at the production level. Facilities became far more computerized, incorporating advanced technologies into the production process. Since 1994, employment in the industry has increased to reach 100,100 in 1997. Even though 1997 employment was about the same as that in 1987, payroll was $1060.8 million more in 1997 than in 1987. The cost of materials has increased over past years, rising from about $29 billion in 1987 to almost $41 billion in 1997. New capital investment averaged $3,955 million a year.

F.2.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. Table F-11 presents the capacity utilization ratios from 1991 to 1997 for the industrial organic chemicals industry. The capacity utilization ratio for the cyclic crudes and intermediaries industry was 82 percent in 1997. The corresponding ratio for the miscellaneous industrial organic chemicals industry was 78 percent.

Table F-10. Inputs: Industrial Organic Chemicals

Year	Labor: Quantity (10^3)	Labor: Payroll (1998 $\$10^6$)	Materials (1998 $\$10^6$)	New Capital Investment (1998 $\$10^6$)	Energy[a] (1998 $\$10^6$)
SIC 2865 Cyclic Crudes and Intermediates					
1987	22.8	946.2	6,619.1	455.7	506.5
1988	23.9	998.3	6,961.7	487.1	556.1
1989	22.8	957.4	7,694.3	641.0	563.5
1990	23.0	992.2	7,654.5	1,040.1	516.6
1991	23.5	1,037.1	7,326.8	769.6	512.4
1992	22.2	1,016.3	6,862.9	587.9	460.1
1993	23.3	1,114.8	7,000.4	726.1	522.6
1994	22.7	1,077.6	7,376.4	623.2	492.6
1995	22.6	1,046.1	7,315.0	863.2	415.5
1996	22.8	1,108.9	7,517.0	1,054.0	566.2
1997	19.3	1,298.9	7,110.9	NA	514.7
SIC 2869 Industrial Organic Chemicals, N.E.C.					
1987	100.3	4,447.4	29,141.0	2,388.9	2,683.0
1988	97.1	4,227.3	30,821.4	3,131.5	2,649.2
1989	97.9	4,323.3	32,257.0	3,818.4	2,697.6
1990	100.3	4,592.4	32,775.1	4,527.0	2,776.5
1991	101.0	4,746.6	33,064.9	4,891.8	2,542.9
1992	100.1	4,898.4	34,644.6	4,585.1	2,773.4
1993	97.8	4,882.6	33,124.4	3,643.8	3,120.8
1994	89.8	4,783.8	35,142.0	3,089.5	3,023.2
1995	92.1	4,906.9	36,137.7	4,153.5	2,755.5
1996	100.3	5,704.2	39,990.5	5,316.0	3,417.1
1997[b]	100.1	5,508.2	40,784.2	NA	2,940.7

[a] Where NAICS code is only partially composed of SIC-coded industry, 1997 statistics on energy use are estimated based on the percentage of NAICS-industry shipments due to the SIC-industry of interest

[b] Excludes 2 firms for which data were unavailable

Sources: U.S. Department of Commerce, Bureau of the Census. 1990g. *1988 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992a. *1990 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufacturers,*

Table F-11. Capacity Utilization Ratios for SICs 2865 and 2869

	1991	1992	1993	1994	1995	1996	1997
SIC 2865	85	89	86	88	84	85	82
SIC 2869	86	81	91	89	84	84	78

Sources: U.S. Department of Commerce, Bureau of the Census. 1999i. *Survey of Plant Capacity: 1997*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1996. *Survey of Plant Capacity: 1994*. Washington, DC: Government Printing Office.

F.2.2 Demand Side of the Industry

F.2.2.1 Product Characteristics

Dyes and pigments are popular for their ability to color materials. Dyes’ properties are much the same as pigments, except they are soluble in the vehicle. Pigments are available in varied qualities. Pigments are rated using the following attributes: tinctorial strength, durability, hiding power, transparency, and heat and solvents resistance. Other properties used to judge pigments are brightness (saturation), gloss, rheology, dispersability, crystal stability, bleed resistance, and other properties associated with specialized applications. These attributes vary greatly, from poor to outstanding. Quality depends on the quality of the raw materials and the process and equipment used to create the pigment. Aromatic chemicals are formulated to affect the smell of various products and are used in cosmetics and household products.

Miscellaneous industrial organic chemicals’ properties are as varied as the chemicals themselves; some are valued for their ability to affect our foods in a positive manner, others are used in war.

F.2.2.2 Uses and Consumers of Products

Dyes and pigments are used for decorative and/or functional purposes. Pigments and dyes are used in a great many light and durable goods and add aesthetic value to the products into which they are incorporated. Dyes are most commonly used to color polyester and cotton, the two most popular fibers. The textile industry and individual consumers both use dyes. However, the textile industry consumes more dyes in terms of volume and value.

Pigments are used in a variety of products ranging from printing inks to plastics. Pigments have a more varied customer base because of their use in plastics, household products, printing, paints of all kinds, cements, waxes, artist materials, and wall paper (to name a few industries), as well as textiles. The worldwide printing ink industry consumes 41 percent of the total value of pigments, paints 29 percent, plastics 23 percent, and special applications 7 percent (see Figure F-1).

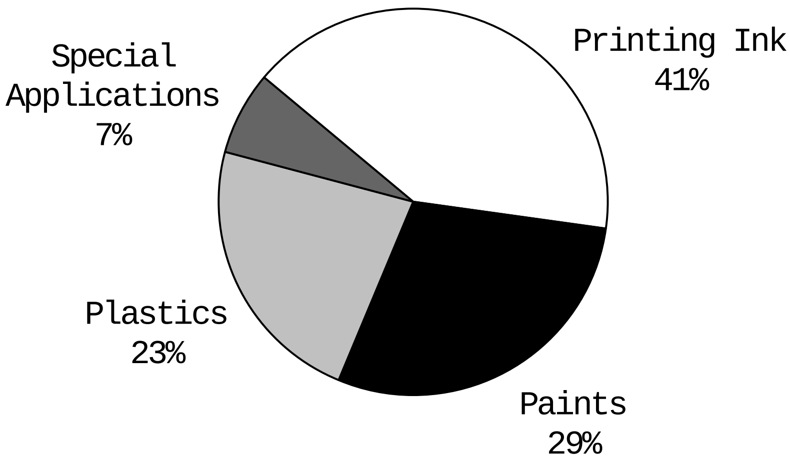


Figure F-1. Worldwide Pigment Consumption by Industry

Miscellaneous industrial organic chemicals uses and consumers are as varied as their products. Common uses and consumers include food products, plastics additives, the flavor and fragrance industry, and others.

F.2.2.3 Substitution Possibilities

Within this industry, there are possible substitutions (e.g., natural flavors rather than artificial flavorings) but for a great many items classified under these two SIC codes substitutes are limited. Substitution possibilities vary depending on the ingredients, tastes and preferences, and customer specifications for each individual product. Historical trends in domestic and foreign consumption of these products are presented in Table F-15 in Section F.2.4.

F.2.3 Organization of the Industry

F.2.3.1 Firm Characteristics

Table F-12 presents data on the number of facilities and value of shipments in these industries. There was a net decrease of 11 percent in the total number of facilities operating in the cyclic crudes industry between 1992 and 1997. However, the decrease in facilities was accompanied by an increase in the real value of shipments. The real value of shipments increased by 18 percent.

Miscellaneous industrial organic chemicals (SIC 2869) experienced a 22 percent increase in the value of shipments between 1992 and 1997. SIC 2869's total value of shipments grew by nearly $13 billion.

Both SIC codes are dominated by large, multinational firms. Many of the largest firms operating in the market are subsidiaries of major European conglomerates, such as Hoechst. In the cyclic crudes and intermediates industry, 150 companies controlled 206 facilities, 143 of which employed more than 20 employees in 1992. In the miscellaneous industrial organic chemicals industry, 489 companies controlled 705 facilities, 428 of which employed more than 20 employees in 1992.

To assess the competitiveness of a market, economists often estimate four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indices (HHI). The four- (eight-) firm concentration ratio indicates the percentage of the industry's total sales that is accounted for by its top four (eight) firms. The closer the concentration ratios are to 100, the more concentrated the industry (more market share concentrated with fewer companies). For SIC 2865, the largest four firms only controlled 31 percent of the total market, indicating the presence of a fairly competitive market. The 1992 Department of Justice's Horizontal Merger Guidelines also provide criteria for interpreting market structure

Table F-12. Size of Establishments and Value of Shipments

Establishments With an Average of	1992 Number of Facilities	1992 Value of Shipments (1998 $\$10^6$)	1997 Number of Facilities	1997 Value of Shipments (1998 $\$10^6$)
SIC 2865 Cyclic Crudes and Intermediates				
1 to 4 employees	26	21.1		
5 to 9 employees	15	37.9		
10 to 19 employees	22	87.9		
20 to 49 employees	40	468.6		
50 to 99 employees	34	790.1		
100 to 249 employees	43	3,370.2		
250 to 499 employees	18	2,901.0		
500 to 999 employees	7	2,732.5		
1,000 to 2,500 employees	1	D		
Total	206	10,409.3	184	12,264.0
SIC 2869 Industrial Organic Chemicals, N.E.C.				
1 to 4 employees	100	111.6		
5 to 9 employees	80	226.9		
10 to 19 employees	97	580.6		
20 to 49 employees	125	1,850.2		
50 to 99 employees	106	3,763.3		
100 to 249 employees	111	9,629.7		
250 to 499 employees	41	10,842.4		
500 to 999 employees	30	14,956.9		
1,000 to 2,499 employees	10	9,841.9		
2,500 or more employees	5	7,191.4		
Total	705	58,994.9	738	72,220.3[a]

D = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990b. *1987 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

based on HHIs. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. The HHI for cyclic crudes and intermediates was 428, less concentrated (i.e., more competitive) (U.S. Department of Justice and Federal Trade Commission, 1992). The HHI for industrial organic chemicals was 336. Table F-13 summarizes the different measures of market structure in the industrial organic chemicals industry.

Table F-13. Measures of Market Concentration by SIC: 1992

	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2865	Cyclic Crudes and Intermediates	31	45	428	150	206
SIC 2869	Industrial Organic Chemicals, N.E.C.	29	43	336	489	705

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

The largest producers in the United States for SIC 2865 are Hoescht Celanese, Occidental Chemical Group ($5,410.0 million), Ciba-Geigy Group ($4,800.0 million), Huntsman Corporation ($4,300 million), and Amoco Chemical Company ($3,723.0 million).

For SIC 2869, the largest producers in the United States are E.I. DuPont de Nemours and Company ($45,193.0 million), Amoco Corporation ($36,112.0 million), Dow Chemical Company, Phillips Petroleum Company ($13,521.0 million), and Ashland Inc. ($12,167.0 million).

F.2.3.2 Geographical Distribution

Companies choose plant locations because of their access to raw materials and proximity to major transportation networks and customers. Available data indicate that, apart from South Carolina, the northern mid-Atlantic states and Illinois dominate cyclic crudes and intermediates production. South Carolina is the state with the largest value of shipments, $864.4 million in 1992. The top five states (by value of shipments) shipped 34 percent of the industry's total value of shipments (see Table F-14).

Table F-14. Industry Statistics for the Top Five States, 1992

State	Value of Shipments (1998 10^6)	Number of Facilities	Facilities With Fewer Than 20 Employees	Number of Employees
SIC 2865 Cyclic Crudes and Intermediates				
South Carolina	864.4	10	1	1,500
New Jersey	847.9	39	14	2,400
New York	670.6	11	1	1,900
Pennsylvania	632.0	17	7	1,700
Illinois	493.1	11	2	1,300
USA	10,409.3	206	63	22,200
SIC 2869 Industrial Organic Compounds, N.E.C.				
Texas	26,615.6	97	21	30,700
Louisiana	8,350.1	31	4	11,100
New Jersey	3,062.3	69	23	8,300
Illinois	2,667.7	37	11	3,300
West Virginia	1,835.9	13	0	4,600
USA	58,995.0	705	277	100,100

Source: U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

Texas dominates the miscellaneous industrial organic chemicals. Texas alone shipped $26,615.6 million worth of product in 1992, 45.1 percent of the national total. The top five states also include Louisiana, New Jersey, Illinois, and West Virginia. These five states were responsible for 72.1 percent of the nation's total value of shipments in 1992.

F.2.4 Markets and Trends

The market for cyclic crudes, intermediates, and miscellaneous industrial organic chemicals grew steadily through 1989, but then dropped in the early 1990s. The market began rebounding in 1994. From 1987 to 1995, there was a net increase in production of 7.1 percent, while consumption grew by 6.8 percent. Table F-15 presents production, consumption, and international trade data for these two industries. We computed apparent domestic consumption to be the difference between domestic production and net exports.

F.2.4.1 Production

Domestic. The miscellaneous industrial organic chemicals industry in recent years has experienced varied performance. The plastics additives industry is going through acquisitions, mergers, investments, and disinvestments that are dragging profits down. Production was projected to grow at a rate of 3 percent a year through 1999 once the consolidations have settled. In contrast, the food additives industry has seen growth due to the emergence of the low-fat foods industry, and the fragrance and flavorings industry has seen the highest rate of growth in SIC 2869 (DRI McGraw Hill, 1998).

Foreign. Almost two-thirds of global dyestuffs exports originate in Western Europe. The United States, Asia, and Brazil make up the remaining 35 percent. Asia is becoming more successful because companies there offer a range of products for relatively low prices. The United States remains the largest market for organic chemicals in the world, importing $15.3 billion (1996) worth of organic chemical products in 1996, nearly $260 million more than it exported that same year.

F.2.4.2 Consumption

Domestic. The quantity of SIC 2865 demanded in 1995 and 1996 rose because of increased light goods and low-fat foods consumption. Some aromatics were stagnant (e.g., xylenes) while other products experienced a booming business (toluene and napthalene). The performance of miscellaneous industrial organic chemicals was understandably mixed, depending on the product.

Foreign. In cyclic crudes and intermediates, the global demand for benzene (aromatic chemicals) doubled in the last 15 years. Toluene and xylene also remain popular. This division of petrochemicals, among others, is growing most in Asia and is being serviced increasingly by the Middle East.

Table F-15. Trends in Domestic Production, Consumption, and Net Exports: SICs 2865 and 2869 (1998 $\$10^6$)

Year	Domestic Production	Domestic Consumption	Net Exports
SICs 2865 and 2869 Combined			
1987	64,367.7	59,704.3	4,663.4
1988	71,576.4	69,854.6	1,721.8
1989	76,390.9	75,342.0	1,048.9
1990	75,119.1	71,161.9	3,957.3
1991	70,164.7	64,632.6	5,532.1
1992	64,645.9	61,506.6	3,139.3
1993	63,548.5	60,161.7	3,386.8
1994	67,489.2	63,571.0	3,918.2
1995	68,936.4	63,789.9	5,146.6

Note: Domestic Consumption = Domestic Production **-** Exports + Imports.

Sources: U.S. Department of Commerce, International Trade Administration. 1989. *1989 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1991. *1991 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1993. *1994 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

DRI McGraw Hill, Standard and Poor's and U.S. Department of Commerce, International Trade Administration. 1998. *U.S. Industry and Trade Outlook 1998*. New York: McGraw Hill.

The United States remains an important exporter of organic chemical products, selling nearly $17.2 billion (1998) dollars worth of chemical products to foreign countries in 1995. The chemicals were sold predominantly to NAFTA, the EU, and Japan.

F.3 Soaps and Cleaners

SIC 284 consists of cleaning products, a medium-sized American industry. Soaps and other detergents (SIC 2841), polishes and sanitation goods (2842), and surface active agents (2843) encompass a wide variety of cleaning agents. The largest market served by these industries is the one for bar soap for personal bathing. In 1997, the total value of this industry's shipments was $32,387.3 million (see Table F-16). All dollar values are 1998 dollars unless otherwise indicated.[1]

The soap and other detergents industry is nearly twice as large, in terms of value of shipments, as the next largest four-digit SIC code grouping, polishes and sanitation goods. Over the period 1987 to 1997, the soap and other detergents industry grew 21.2 percent in real terms. The industries comprising this SIC produce soap, synthetic organic detergents, and inorganic alkaline detergents in addition to crude and refined glycerin from vegetable and animal fats.

The polishes and sanitation goods industry shipped $8,434.4 million worth of goods in 1997, an increase of 25.3 percent since 1987. Firms engaged in this industry produce polishes for metals and furniture; household bleaches; waxes; and household, institutional, and industrial disinfectants.

The surface active agents industry's value of shipments was fairly steady between 1987 and 1996. In 1997, the industry experienced significant growth, shipping $7,046.6 million dollars worth of product that year, 45 percent more than in 1996. Surface active preparations are used as emulsifiers, wetting agents, and penetrants in soaps and detergents.

F.3.1 Supply Side of the Industry

F.3.1.1 Production Processes

Soap and detergent manufacturing differs depending on the final form of the product: liquid (including gel), powdered, or bar. However, the first step in the manufacturing process, choice of inputs, is similar in theory across all three processes. Soap and allied

[1]Values adjusted using the plant cost index published in *Chemical Engineering*, various years.

Table F-16. Value of Shipments (1998 $$10^6$)

Year	SIC 2841 Soap and Other Detergents	SIC 2842 Polishes and Sanitation Goods	SIC 2843 Surface Active Agents	Totals
1987	13,903.8	6,728.9	3,611.4	24,244.0
1988	13,995.1	6,661.6	3,864.8	24,521.5
1989	14,554.9	6,561.9	3,243.2	24,359.8
1990	16,744.7	6,369.6	3,450.9	26,565.1
1991	16,492.4	6,653.2	4,087.5	27,233.1
1992	16,050.7	7,259.6	3,114.3	26,424.6
1993	16,798.3	8,783.2	3,974.7	29,556.0
1994	15,452.2	9,206.1	5,170.8	29,829.1
1995	16,487.5	8,590.2	3,802.7	28,880.4
1996	16,100.9	8,777.4	4,838.2	29,716.6
1997	16,906.3	8,434.4	7,046.6	32,387.3

Sources: U.S. Department of Commerce, Bureau of the Census. 1995h. *1992 Census of Manufactures, Industry Series: Soaps, Toilet Goods, and Cleaners*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1998. *1996 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999e. *1997 Census of Manufactures, Industry Series: Polish and Other Sanitation Goods Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999f. *1997 Census of Manufactures, Industry Series: Surface Active Agent Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999g. *1997 Census of Manufactures, Industry Series: Soap and Other Detergent Manufacturing*. Washington, DC: Government Printing Office.

products inputs are chosen using the following guidelines: human and environmental safety, cost, compatibility with other ingredients, and the form and characteristics of the final product.

The basic ingredients are surfactants(or surface active agents) and builders. Surfactants change the properties of water, effectively reducing the surface tension of water to enable the cleaning solution to wet a surface more quickly so dirt and oils can be more easily and quickly removed. Surfactants also work to keep oils and dirts from settling back into their previous positions.

There are four categories of surfactants, based on their ionic properties: aionic, nonionic, cationic, and amphoteric. Aionic are used in laundry, hand dishwashing, and personal cleansing products. They create the greatest amount of suds. Nonionic surfactants are used in low-suds products such as laundry and dishwasher detergents. Cationic surfactants are used primarily by fabric softening companies. Finally, amphoteric surfactants are used primarily in personal cleansing and cleaning products because their charges change depending on the pH level of the water, making them very flexible.

Builders are used to reduce water hardness to allow the surfactants to function more efficiently. They also help prevent oils and dirt from resettling.

Solids (Nonpowder). Solid products are produced by mixing fatty acids with inorganic water-soluble bases. Most fats are extracted from beef and mutton tallow or palm, coconut, and palm kernel oils. The fats and oils undergo a process called saponification (heating fats and oils and reacting them with liquid alkali to produce soap, water, and glycerine).

There are two general processes of making soap; continuous and batch processing. Continuous processing is most often used because of its flexibility and speed relative to the time-consuming and inefficient batch process. Both processes initially produce soap in a liquid form (referred to as neat soap). Liquid soap is separated from glycerine through saponification. Vacuum spray drying is used to reduce the neat soap into dry soap pellets. The amount of moisture allowed to remain in the soap pellets varies. Manufacturers determine the consistency of the soap at this stage. The pellets then pass through a mixer and are blended together with fragrances and other additives. Next, the mixture is homogenized and refined through rolling mills before being sliced into bars and molded into its final shape with a soap press.

Powdered Detergents. Manufacturers can produce powdered detergents using three processes: spray drying, agglomeration, or dry mixing.

In spray drying, the liquid and dry components of the detergent are combined in a machine known as a crutcher. The mass is then heated and sprayed under high pressure to produce small droplets. The droplets form small granules as they fall and dry. Fragrances and other additives are added before the product is packaged for shipment.

In agglomeration, high density powders are produced by mixing together dry raw materials with liquid ingredients. Next, a liquid binder is added. The mixture is then rolled and mixed, forcing the materials to adhere to each other. The large particles are then broken down to a finer dust.

In dry mixing, the materials are simply mixed together using only minor amounts of liquid.

Liquids. The process by which a manufacturer creates liquid detergents is similar to that used to manufacture solid product. The materials are blended together in the same fashion; however, they are not allowed to dry, and stabilizers are often added to maintain proper dispersion of active ingredients in the liquid or gelled matter.

F.3.1.2 Major By-products and Co-products

The most significant co-product of cleaning products manufacturing is glycerine. Glycerine producers are grouped under SIC 2841. An important industrial material, glycerine is removed from the production line after saponification. It is then treated and refined for use in foods, cosmetics, drugs, and other products.

F.3.1.3 Types of Output

The following products are produced by these industries:

- personal cleaning products: bars, soaps, liquid cleaning products, heavy-duty hand cleaners;
- laundry detergents and aids: liquids, powders, gels, sticks, powders, pastes, sheets, and sprays; bleaches; bluings, enzyme presoaks, fabric softeners, starches, water softeners;
- dishwashing products: automatic detergents, rinse agents, film removers; lime and rust removers;

- household, institutional, and industrial cleaning products and polishes: all-purpose cleansers, abrasive cleansers, clear-surface cleaners, metal cleaners and polishes, tile cleaners, oven cleaners, rug and other surface shampoos, drain openers, and toilet cleaners; and
- cleanser ingredients: wetting agents, emulsifiers, and penetrants.

F.3.1.4 Costs of Production

During the late 1980s and early 1990s, the soaps and other detergents industry (SIC 2841) grew, adding nearly 5,000 workers, an increase of 15.5 percent, between 1987 and 1991 (see Table F-17). After the recession, however, the industry begun reducing its quantity of labor inputs. Even though the value of shipments was 21.6 percent higher in 1997 than in 1987, employment was 8.5 percent lower. For the 1987 to 1997 period, payroll rose 3.7 percent and the cost of materials by only 3.3 percent. Energy costs also dropped noticeably during the mid-1990s. New capital investment for the 10 years presented averaged $506.6 million a year.

SIC 2842, polishes and sanitation goods, followed a more conventional pattern from 1987 to 1997. The 25.3 percent increase in the real total value of shipments (shown in Table F-16) was accompanied by increases in costs of production. From 1987 to 1997, employment increased 6.7 percent to reach 22,000. Payroll grew to $730.2 million, an increase of 21.3 percent. The largest increase was in the area of raw materials cost; increasing 37.5 percent from 1987 to 1997. Energy costs were $4.5 million higher in 1997 than in 1987. New capital investment averaged $136.3 million a year.

From 1987 to 1995, surface active agents manufacturers, SIC 2843, experienced a general rise in costs, indicating that the 95 percent rise in the value of shipments may not have been accompanied by a commensurate rise in industry profits. In 1997, employment was 4.3 percent higher than in 1987. The payroll was 29 percent higher in 1997 than 1987. Such significant increases in payroll indicate that labor become may have become productive over this time period. Over this same time period, the costs of materials rose by 45 percent. New capital investment averaged $156.2 million over these 9 years. Energy expenditures rose 36.3 percent.

F.3.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is

Table F-17. Inputs: Soaps and Cleaners

Year	Labor: Quantity (10^3)	Labor: Payroll (1998 $\$10^6$)	Materials (1998 $\$10^6$)	New Capital Investment (1998 $\$10^6$)	Energy (1998 $\$10^6$)
SIC 2841 Soap and Other Detergents					
987	31.7	1,149.6	6,824.5	407.5	126.6
1988	33.3	1,150.7	6,818.7	418.9	137.0
1989	34.8	1,198.0	7,441.5	434.1	130.7
1990	36.3	1,304.6	8,178.8	518.2	127.4
1991	36.6	1,315.9	7,717.5	680.0	126.8
1992	32.9	1,278.7	7,568.3	621.3	130.2
1993	31.4	1,246.2	7,799.4	557.2	132.9
1994	31.3	1,237.8	7,497.6	523.0	117.0
1995	32.1	1,258.7	7,069.8	371.6	102.0
1996	30.3	1,196.5	6,845.6	435.6	100.5
1997	29.0	1,191.9	7,051.3	NA	101.8
SIC 2842 Polishes and Sanitation Goods					
1987	20.6	601.9	2,338.2	141.6	37.6
1988	20.5	571.0	2,399.3	81.5	37.1
1989	21.2	609.0	2,520.1	154.7	36.7
1990	19.6	579.7	2,361.2	103.4	34.6
1991	19.6	618.1	2,462.1	147.7	36.1
1992	22.0	720.3	2,678.7	132.1	37.7
1993	22.9	689.2	3,222.0	141.4	42.5
1994	21.4	691.9	3,108.1	131.1	40.2
1995	23.0	717.7	3,273.9	158.1	43.5
1996	24.2	752.2	3,218.5	176.3	45.1
1997	22.0	730.2	3,215.0	NA	42.1
SIC 2843 Surface Active Agents					
1987	9.1	348.6	2,025.4	124.4	105.3
1988	9.0	337.2	2,326.1	218.0	103.8
1989	9.0	341.7	1,941.7	141.6	75.8
1990	9.1	361.8	2,119.3	179.7	78.1
1991	9.3	366.0	2,182.9	169.6	77.9
1992	8.2	348.3	1,837.1	100.5	72.1
1993	8.6	388.9	2,267.2	220.6	104.2
1994	8.1	368.6	2,247.3	237.6	103.9
1995	8.0	351.0	2,476.1	125.2	96.2
1996	8.8	408.5	2,584.2	164.4	129.6
1997	9.5	466.3	3,051.4	NA	143.5

NA = not available.

Sources: U.S. Department of Commerce, Bureau of the Census. 1995h. *1992 Census of Manufactures, Industry Series: Soaps, Toilet Goods, and Cleaners*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufactures, Industry Series*. Washington, DC: Government Printing Office.

the ratio of actual production level to the full production capacity level. Table F-18 presents the historical trends in the capacity utilization rates for the soaps and detergents (SIC 2841), the polishes and sanitation goods (SIC 2842), and the surface active agents (SIC 2843) industries.

Table F-18. Capacity Utilization Ratios for Sics 2841, 2842, and 2843

	1992	1993	1994	1995	1996	1997
SIC 2841	74	70	72	57	58	66
SIC 2842	68	75	76	57	69	60
SIC 2843	85	71	82	68	72	67

Source: U.S. Department of Commerce, Bureau of the Census. 1996. *Survey of Plant Capacity: 1994.* Washington, DC: Government Printing Office.

F.3.2 Demand Side of the Industry

F.3.2.1 Product Characteristics

Soaps and allied products can be used to remove dirts and oils from a variety of surfaces including plastic, tile, metal, fabric, concrete, Formica, stone, and wood. More recently, they have been combined with antibacterial elements to disinfect as they clean. Cleaning products can also be formulated to suit a particular consumer's needs.

At the household level, soaps are one of the key components of personal hygiene. In addition to being able to remove dirt and oil off bodies, these products also fight bacteria. They are available in powder, liquid, or solid form, and their versatility in application boosts their popularity.

F.3.2.2 Uses and Consumers of Products

There are four general categories of consumers and users of these products: personal, household, commercial, and industrial. SIC 2843, surfactants, produces intermediate goods used in soaps and polishes. The consumers of these products are the corporations involved with manufacturing products for the consumer groups listed above. Many goods are used by more than one category. For instance, car manufacturers may be industrial consumers when using cleaners during the production process, but they are also institutional users when using these products to clean their offices.

Individuals use personal soaps and cleaning products for hygienic reasons. Bar soaps remove dirt and oils and have recently been formulated to neutralize bacteria.

At the household level, cleaners and polishes are produced for a variety of surfaces, such as glass, leather, rugs, tile, cast iron, fiber glass, furnishings (both wood and metal), and carpeting. A significant portion of these products is devoted to cleaning fabrics or increasing the softness of these products.

At the commercial level, these goods are produced in concentrations and quantities for large outfits such as hospitals, clinics, and other entities. The commercial laundering sector, such as dry cleaners and other such institutions, are also large consumers.

The industry also uses these products for cleaning vats, industrial surfaces, or products during the intermediate and final stages of production. For instance, the paint industry cleans its vats and system after deciding on a color change. Another example is the automobile industry, which must clean the body of its product before and after the paint and enameling process.

Historical statistics on domestic and foreign production and consumption of these products are presented in Table F-22 in Section F.3.4.

F.3.2.3 Substitution Possibilities

In many respects, no products can substitute for cleaning agents. Within the industry itself, however, liquids, solids, and powders are substitutes. One medium, or vehicle, can substitute for another; however, both individual and industrial consumers purchase more products in liquid and solid form.

F.3.3 Organization of the Industry

F.3.3.1 Firm Characteristics

In the soaps and detergents industry, less than 739 companies controlled 760 facilities in 1997, up from 635 companies controlling 710 facilities in 1992. In 1992, 694 companies controlled 749 facilities producing polishes and sanitation goods. By 1997, only 676 companies controlled 728 establishments. In the surfactants industry, 184 companies operated 211 establishments in 1997, a slight increase over 1992 when 176 companies operated 205 facilities. In all three industries, facilities with more than 50 employees produce the majority of product. For soaps and detergents, firms with between 50 and 999 employees shipped $15,311.3 million in product in 1997, or 91 percent of the industry total (see Table F-19). Facilities with more than 50 employees involved in polishes and sanitation goods accounted for 84.3 percent of the industry total. The same trend is true of surfactants where facilities with more than 50 employees accounted for 83.3 percent of the industry's total value of shipments.

To assess the competitiveness of a market, economist often estimate four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indices (HHI). The CR4 for soaps and detergents in 1992 was 63, meaning that the top four firms accounted for 63 percent of the industry's total sales. The CR8 for the same year was 77. The CR4 and CR8 for polishes and sanitation goods were 52 and 59, respectively. For surfactants, the CR4 was 37 and the CR8 53 (U.S. Department of Commerce, 1995a). Based on concentration ratios, the soaps and detergents industry appears to be the most concentrated of the three industries studied in this profile. Firms in more-concentrated industries are more likely to be able to influence market prices.

The 1992 Department of Justice's Horizontal Merger Guidelines also provides criteria for determining market structure based on HHIs. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). In 1992, the HHI for soaps and detergents was 1,584; therefore, the industry is considered to be only moderately competitive. The HHI for polishes and sanitation goods was 817 (i.e., more competitive). The surface active agents industry is also more competitive, with an HHI of 471 (U.S. Department of Commerce, 1995a). Table F-20 summarizes the various measures of market structure for the industries in question.

The largest producers for SIC 2841 in the United States are Proctor and Gamble Company ($35,800.0 million in sales), Dow Chemical Company ($20,053.0 million), Unilever United States Inc. ($9,000.0 million), Colgate-Palmolive ($8,749.0 million), and Amway Corporation ($6,800.0 million).

Table F-19. Size of Establishments and Value of Shipments

Establishments With an Average of	1992 Number of Facilities	1992 Value of Shipments (1998 $\$10^6$)	1997 Number of Facilities	1997 Value of Shipments (1998 $\$10^6$)
SIC 2841 Soaps and Other Detergents				
1 to 4 employees	234	108.0	274[a]	126.2a
5 to 9 employees	140	230.1	151[a]	247.2a
10 to 19 employees	108	325.6	124[a]	394.1a
20 to 49 employees	108	924.8	107[a]	827.4a
50 to 99 employees	53	1,178.4	46[a]	1,186.8a
100 to 249 employees	37	2,058.6	34[a]	3,232.1a
250 to 499 employees	20	5,873.2	18[a]	6,785.3a
500 to 999 employees	9	5,352.2	4[a]	D
1000 employees or more	1	D	2[a]	D
Total	710	16,050.8	760[a]	16,906.2[a]
SIC 2842 Polishes and Sanitation Goods				
1 to 4 employees	289	141.0	294	106.8
5 to 9 employees	125	166.8	127	145.5
10 to 19 employees	110	264.5	95	332.9
20 to 49 employees	121	965.8	100	740.2
50 to 99 employees	50	1,112.6	62	1,465.8
100 to 249 employees	41	1,723.3	35	2,497.0
250 to 499 employees	11	2,885.7	12	1,068.3
500 to 900 employees	1	D	2	D
1,000 to 2,500 employees	1	D	1	D
Total	749	7,259.7	728	8,434.4
SIC 2843 Surface Active Agents				
1 to 4 employees	50	34.1	47	177.4
5 to 9 employees	33	76.1	26	92.6
10 to 19 employees	32	159.6	35	198.6
20 to 49 employees	44	492.9	52	709.1
50 to 99 employees	24	695.2	28	1,007.5
100 to 249 employees	16	815.3	18	1,248.2
250 to 499 employees	6	841.1	3	D
500 to 999 employees	0	0	2	D
Total	205	3,114.4		7,068.5

[a]estimated based on the composition of NAICS coded industry 325611
D = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1989. *1987 Census of Manufactures, Industry Series: Soaps, Toilet Goods, and Cleaners*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995h. *1992 Census of Manufactures, Industry Series: Soaps, Toilet Goods, and Cleaners*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufactures, Industry Series*. Washington, DC: Government Printing Office.

Table F-20. Measures of Market Concentration by SIC: 1992

	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2841	Soaps and Detergents	63	77	1,584	635	710
SIC 2842	Polished and Sanitation Goods	52	59	817	694	749
SIC 2843	Surface Active Agents	37	53	471	176	205

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995h. *1992 Census of Manufactures, Industry Series: Soaps, Toilet Goods, and Cleaners*. Washington, DC: Government Printing Office.

For SIC 2842, the largest producers in the United States are Dow Chemical, S.C. Johnson and Son Inc. ($3,000 million), DuPont Automotive Products ($3,000.0 million), Olin Corporation ($2,637.9 million), and Modern Bionics ($2,230.0 million).

For SIC 2843, the largest producers in the United States are BF Goodrich Company ($2,238.0 million), Akzo Nobel Inc. ($1,700.0 million), Stephan Company ($536.6 million), Henkel Corporation Chemical Group ($300.0 million), and Milpark Drilling Fluids ($210.0 million).

F.3.3.2 Geographical Distribution

In 1992, the soaps and other detergents industry was dominated by firms in Ohio, Michigan, California, Georgia, and Missouri. The total value of shipments in 1992 for firms located in these states was $8,608.1 million, or 53.6 percent of the national total (see Table F-21).

Ohio, Georgia, and Missouri join Illinois and New Jersey as the top five states for polishes and sanitation goods. In 1992, these states' total value of shipments accounted for 41.7 percent of the national value, or $3,030.5 million.

Table F-21. Industry Statistics for the Top Five States, 1992

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees)	Number of Employees
SIC 2841 Soaps and Other Detergents				
Ohio	3,070.5	43	22	4,000
Michigan	1,802.1	42	34	5,000
California	1,505.9	99	62	3,000
Georgia	1,118.3	29	13	2,200
Missouri	1,111.3	26	19	1,800
USA	16,050.7	710	482	32,900
SIC 2842 Polishes and Sanitation Goods				
Illinois	814.1	53	31	2,200
New Jersey	629.7	35	23	1,300
Ohio	576.0	34	17	1,900
Georgia	526.7	28	18	1,300
Missouri	484.0	24	12	1,100
USA	7,259.6	749	524	22,000
SIC 2843 Surface Active Agents				
Illinois	684.6	16	5	1,500
South Carolina	299.5	20	8	800
Texas	287.1	12	6	600
North Carolina	266.4	25	16	900
New Jersey	265.8	23	13	800
USA	3,114.3	205	115	8,200

Source: U.S. Department of Commerce, Bureau of the Census. 1995h. *1992 Census of Manufactures, Industry Series: Soaps, Toilet Goods, and Cleaners*. Washington, DC: Government Printing Office.

Illinois was the dominant manufacturing state in the surfactants industry with $684.6 million in shipments in 1992. Along with South Carolina, Texas, North Carolina, and New Jersey, Illinois contributed 57.9 percent of the nation's total value of shipments for that year—$1,803.4 million.

F.3.4 Markets and Trends

F.3.4.1 Production

Table F-22 depicts the trends in U.S. production and consumption of soaps, cleaners, polishes, and other goods. The last column shows the net exports (exports minus imports) of these industries. Between 1987 and 1995, domestic production of soap and other detergent increased by 10.8 percent (in terms of value of shipments) to meet a 7.5 percent increase in domestic consumption, and a dramatic 545 percent increase in net exports. A similar trend was evident in the polishes and sanitation goods industry. Production increased by 19.3 percent between 1987 and 1995, while consumption went up by 18.5 percent, and net exports by 653 percent. Note that net exports appear to increase dramatically because they are small relative to total production. Although production and consumption of surface active agents declined over the same period, production did not decline as much as consumption partly because of strong sales to foreign markets.

Domestic. Domestic producers are continuing to adapt to the increasingly global markets for all three industries. Supply and distribution networks, like the corporations that maintain them, have become more integrated internationally.

Another issue facing domestic producers is concentrated products. Europe, Australia, and Japan have switched to concentrated products; however, American household and industrial consumers have been slow to respond to new products. Manufacturers believe that Americans must be educated before they will accept changes in the use and nature of their everyday products.

Shipments of soaps and detergents are expected to grow 2 percent annually through the end of the century. Polishes and sanitation goods are expected to grow at 1 percent over the same period, and surfactants by 1 to 2 percent annually (DRI McGraw Hill, 1998).

Foreign. In 1996, the United States imported roughly $561.35 million (in nominal terms) worth of soap, cleansing, and polishing products and preparations, mainly from NAFTA countries and the European Union.

Table F-22. Production and Consumption Trends, 1987 to 1995 (1998 $\$10^6$)

Year	Domestic Production	Domestic Consumption	Net Exports
SIC 2841 Soaps and Detergents			
1987	14,682.6	14,758.0	75.3
1988	14,827.6	14,887.6	60.0
1989	15,530.6	15,386.7	143.8
1990	17,752.4	17,528.3	224.1
1991	16,845.5	16,480.0	365.5
1992	16,050.7	15,648.4	402.3
1993	16,603.4	16,182.2	421.2
1994	15,105.1	14,711.1	394.0
1995	16,279.2	15,868.4	410.7
SIC 2842 Polishes and Sanitation Goods			
1987	7,105.9	7,038.6	67.3
1988	7,057.9	6,964.9	92.9
1989	7,001.7	6,947.3	54.3
1990	6,752.9	6,665.8	87.1
1991	6,795.6	6,689.3	106.3
1992	7,259.6	7,153.0	106.6
1993	8,681.3	8,563.5	117.8
1994	8,999.4	8,877.6	121.7
1995	8,481.6	8,337.3	144.3
SIC 2843 Surface Active Agents			
1987	3,813.7	3,433.8	379.8
1988	4,094.7	3,866.5	228.2
1989	3,460.6	3,157.7	302.9
1990	3,658.5	3,276.4	382.2
1991	4,175.0	3,817.2	357.8
1992	3,114.3	2,690.2	424.1
1993	3,928.6	3,546.0	382.6
1994	5,054.6	4,567.4	487.2
1995	3,754.6	3,256.1	498.5

Note: Domestic Consumption = Domestic Production - Exports + Imports

Sources: U.S. Department of Commerce, International Trade Administration. 1989. *1989 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995h. *1992 Census of Manufactures, Industry Series: Soaps, Toilet Goods, and Cleaners*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1993. *1994 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

DRI McGraw Hill, Standard and Poor's, and U.S. Department of Commerce, International Trade Administration. 1998. *U.S. Industry and Trade Outlook 1998*. New York, McGraw Hill.

F.3.4.2 Consumption

Domestic. Demand for soaps and other detergents has been changing; both household and industrial consumers' preferences have shifted toward liquid products. Analysts at *Chemical Week* project that liquids will soon comprise 50 percent of the market (D'Amico, 1996). Liquid products currently comprise 43 percent of the soap and detergent market. Consumption of surfactants for home use is expected to increase 4.5 percent a year through 2005. Bleaches and other cleaning compounds (SIC 2842) are not predicted to penetrate the U.S. market any further. Although 2.9 percent growth is expected through 2000, the industry is mature. Future growth should match the growth in gross domestic product.

Foreign. In 1996, the United States exported $1.3 billion (in nominal terms) worth of soap, cleansing, and polishing products and preparations. The United States's main trading partners are NAFTA members, the European Union, and East Asia.

F.4 Agricultural Chemicals

Nitrogenous (SIC 2873), phosphatic (SIC 2874), and mixing-only (SIC 2875) fertilizers account for an increasingly large portion of the U.S. agricultural chemical industry's revenue each year. In 1992, the value of shipments of the entire agricultural chemicals industry (SIC 287) was $20,494.5 million in 1998 dollars. As shown in Table F-23, the fertilizer industry contributed $11,000.7 million (53.7 percent) to that total; the rest was contributed by agricultural chemicals not-elsewhere-classified (SIC 2879). In 1997, the value of fertilizer shipments was $12,927.2 million in 1998 dollars. The phosphatic fertilizer industry accounted for 45 percent of those shipments. The nitrogenous and mixing-only fertilizer industries accounted for 29 and 26 percent, respectively. Unless otherwise indicated, all values cited in this report are in 1998 dollars. The Standard Industrial Classification (SIC) codes of the fertilizer industries correspond exactly to North American Industry Classification System (NAICS) manufacturing codes as shown in Table F-24.

Companies in SIC 2873, nitrogenous fertilizers, produce fertilizers from nitrogenous materials produced in the same establishment. Manufacturers produce ammonia fertilizer compounds, anhydrous ammonia, nitric acid, ammonium nitrate, ammonium sulfate and nitrogen solutions, urea, and natural organic fertilizers (except compost), and mixtures. Ammonium nitrate, created by reacting nitric acid with anhydrous ammonium, is highly combustible and was for many years the world's most popular fertilizer. But urea with its higher nitrogen content and ability to be stored more safely has eclipsed ammonium nitrate.

Table F-23. Value of Shipments (1998 $\$10^6$)

Year	SIC 2873 Nitrogenous Fertilizers	SIC 2874 Phosphatic Fertilizers	SIC 2875 Fertilizers, Mixing Only
1987	2,943.7	4,594.2	2,046.3
1988	3,129.6	5,071.5	2,120.0
1989	3,108.5	4,541.7	2,007.3
1990	3,377.8	5,029.9	2,198.9
1991	3,609.2	5,554.9	2,106.8
1992	3,645.3	4,975.3	2,380.1
1993	4,016.7	4,230.1	2,461.4
1994	4,853.7	5,254.3	2,561.5
1995	4,859.9	5,857.2	2,699.4
1996	4,465.1	5,800.6	2,442.0
1997	3,793.3	5,793.9	3,340.0

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Agricultural Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC, Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufacturers, Industry Series*. Washington DC, Government Printing Office.

Phosphatic fertilizer plants (SIC 2874) produce a host of complementary products such as phosphoric acid; normal, enriched, and concentrated superphosphates; ammonium phosphates; nitrophosphates; and calcium metaphosphates. The most popular phosphatic fertilizer is diammonium phosphate (DAP).

SIC 2875, mixing-only fertilizers, comprises establishments that purchase fertilizer materials and then mix them. Lately, preferences have been shifting away from mixing fertilizers. Some people have argued that mixing fertilizers are inappropriate because they are not adaptable to varying soil quality. Many governments prefer single-nutrient fertilizers applied in appropriate quantities.

Table F-24. The Correspondence Between SIC Codes 2873, 2874, and 2875 and the NAICS

SIC Code	Description	NAICS Code(s)	Description
2873	Nitogenous fertilizers	325311	Nitrogenous fertilizer manufacturing
2874	Phosphatic fertilizers	325312	Phosphatic fertilizer manufacturing
2875	Fertilizers, mixing-only	325314	Fertilizer (mixing-only) manufacturing

Source: U.S. Department of Commerce, Bureau of the Census. 1997 NAICS and SIC Correspondence Tables. <http://www.census.gov/epcd/www/naicstab.htm>. As obtained March 6, 2000.

F.4.1 Supply Side of the Industry

F.4.1.1 Production Processes

Nitrogenous Fertilizers. Almost all nitrogenous fertilizers are derived from synthetic ammonia. A purified hydrogen-nitrogen mixture undergoes catalytic reaction under high pressure and temperature. The catalyst is specially activated iron. Unreacted gases are recycled, but the ammonia that forms is condensed with liquefied ammonia, creating synthetic ammonia.

Directly applied synthetic ammonia is known as anhydrous ammonia. Further processing produces the following products:

- Aqua ammonia is anhydrous ammonia in a water solution.
- Ammonium nitrates are either straight ammonium nitrates, ammonium sulfate nitrates, or calcium ammonium nitrates. They begin as solutions that are then heated and cooled to form granulated solids. Manufacturers may use a heated dryer to spur the production process along.
- Synthetic urea is produced by reacting ammonia with cyanuric acid. It is less expensive to produce because nitric acid is not required in its production.
- Nitrogen solutions (soluble products) and ammonium sulfate (ammonia combined with sulfur) are also produced.

Phosphatic Fertilizers. All phosphatic fertilizers are derived from mineral phosphates. Phosphate ore is mined, washed, and pulverized. It can then be applied directly as a fertilizer, or it can undergo further production to create other kinds of fertilizer.

Further production processes include

- reacting phosphate rock with sulfuric acid to produce normal superphosphate;
- solubizing ore in sulfuric acid, then filtering the solution to produce wet-process phosphoric acid with some benign impurities;
- reacting ore with phosphoric acid to produce the more-concentrated triple superphosphates; and
- reacting wet-process phosphoric acid and anhydrous ammonia together to form diammonium phosphate.

Other variations include drying wet-process acid to form monoammonium phosphate, increasing the amount of feed acid in production to yield ammonium polyphosphate, and reacting nitric acid with phosphate rock to produce nitric phosphate.

Mixing-Only Fertilizers. The single-nutrient fertilizers produced by the processes described above are mixed to produce various combinations of mixing-only fertilizers. The resultant multinutrient fertilizers use phosphorus, nitrogen, or potash as active agents. These fertilizers are available in liquid, solid, or powdered form.

F.4.1.2 Major By-products and Co-products

The by-products of production (sulfur and ammonia) are captured to produce ammonium sulfate fertilizer. Dry blending produces a granulated product that is increasingly marketed on the global market. Another by-product is sulfuric acid (from phosphatic fertilizer production).

F.4.1.3 Types of Output

The main nitrogenous fertilizers in the United States are

- anhydrous ammonia,
- synthetic urea,
- aqua ammonia,

- ammonium nitrate,
- nitrogen solutions, and
- ammonium sulfate.

The main phosphatic fertilizers are

- direct application rock,
- normal superphosphate,
- wet-process phosphoric acid,
- triple (concentrated) superphosphate,
- diammonium phosphate,
- monoammonium phosphate,
- ammonium polyphosphate, and
- nitric phosphate.

Mixing-only fertilizers are available in any stable combination of the above in either granulated or fluid form.

F.4.1.4 Costs of Production

The most important input for nitrogenous fertilizer production is natural gas. Natural gas aids in the production of ammonia and is a preferred source of hydrogen for the fertilizer industry. The price of natural gas in the United States has increased significantly over the past decade, putting inflationary pressure on fertilizer prices. However, the cost of materials in general has only increased by 14 percent from 1987 to 1997. Labor inputs increased 78 percent from 1987 to 1994, but then dropped 31 percent by 1997 (see Table F-25). The overall increase in employment from 1987 to 1997 was 22 percent. Despite an overall increase in employment, payroll was actually 2.6 percent lower in 1997 than in 1987. Stricter environmental regulations have spurred an increase in research and development, which averaged $143.2 million a year over the 1987 to 1995 period.

In the phosphatic fertilizer industry, employment dropped 5.3 percent, but payroll rose by 11 percent between 1987 and 1997. Research and development expenditures followed the same trend as those for nitrogenous fertilizers.

Table F-25. Inputs: Agricultural Chemicals

Year	Labor Quantity (10^3)	Labor Payroll (1998 $\$10^6$)	Materials (1998 $\$10^6$)	New Capital Investment (1998 $\$10^6$)	Energy (1998 $\$10^6$)
SIC 2873 Nitrogenous Fertilizers					
1987	4.5	268.0	1,808.6	44.3	503.6
1988	4.4	252.5	1,849.6	54.8	509.9
1989	4.4	253.8	1,889.8	134.5	522.3
1990	4.8	276.2	2,075.3	108.3	510.4
1991	4.7	280.5	2,136.8	237.4	478.9
1992	4.7	280.1	2,035.3	227.0	414.9
1993	7.0	293.2	2,297.5	201.6	467.3
1994	8.0	326.0	2,382.1	184.7	499.2
1995	7.3	306.9	2,042.4	179.6	432.9
1996	7.5	320.0	2,152.9	310.9	649.4
1997	5.5	271.4	2,066.8	NA	483.4
SIC 2874 Phosphatic Fertilizers					
1987	9.4	342.2	3,139.0	76.5	155.3
1988	10.4	369.3	5,088.1	152.1	172.6
1989	10.8	381.9	4,589.1	144.8	146.7
1990	10.5	396.5	3,771.2	149.8	153.3
1991	10.3	397.1	3,901.8	212.5	142.7
1992	9.5	372.0	3,345.2	334.6	129.5
1993	9.4	361.0	2,850.1	162.5	146.9
1994	8.5	358.7	3,181.6	168.6	125.2
1995	8.6	367.9	3,566.4	199.2	115.1
1996	7.8	343.2	3,675.8	203.6	130.8
1997	8.9	380.2	3,667.6	NA	159.8
SIC 2875 Fertilizers, Mixing Only					
1987	7.5	174.6	1,492.1	31.7	20.2
1988	7.5	166.0	1,563.9	18.4	26.1
1989	6.4	151.2	1,504.9	29.1	17.6
1990	7.1	178.2	1,596.0	33.9	23.0
1991	6.7	169.6	1,556.5	28.4	21.3
1992	6.9	197.8	1,699.3	47.5	30.4
1993	6.7	193.9	1,705.0	36.7	31.6
1994	7.8	214.5	1,684.9	40.3	27.4
1995	8.4	269.4	1,618.3	92.4	31.9
1996	7.7	278.4	1,556.4	58.4	43.8
1997	8.7	235.9	2,334.2	NA	30.6

Sources: U.S. Department of Commerce, Bureau of the Census. 1990g. *1988 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992a. *1990 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Agricultural Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC, Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufactures, Industry Series*. Washington, DC: Government Printing Office.

The mixing-only fertilizer industry's costs and trends are affected by trends in the nitrogen and phosphatic fertilizer industries. A 16 percent increase in employment is matched by a 35 percent increase in payroll expenses between 1987 and 1997. Increased production was accompanied by increases in the cost of raw materials and vice versa. Because this industry mixes nitrogenous and phosphatic fertilizer products, their trends and costs have a direct impact on this industry.

F.4.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. Table F-26 presents the historical trends in capacity utilization for the fertilizer industry. The data indicate that plants manufacturing nitrogenous fertilizers (SIC 2873) and phosphatic fertilizers (SIC 2874) have been operating near full capacity, whereas plants manufacturing mixing-only fertilizers (SIC 2875) have been operating below capacity.

Table F-26. Capacity Utilization Ratios for SICs 2873, 2874, and 2875

	1991	1992	1993	1994	1995	1996	1997
SIC 2873	91	92	90	93	97	96	92
SIC 2874	89	94	84	87	99	98	94
SIC 2875	54	56	77	77	70	71	50

Source: U.S. Department of Commerce, Bureau of the Census. 1996. *Survey of Plant Capacity: 1994*. Washington, DC: Government Printing Office.

F.4.2 Demand Side of the Industry

F.4.2.1 Product Characteristics

Fertilizers deliver nutrients to soils that lack them, increasing the land's productivity. It is estimated that without fertilizers, the world would need to place 30 percent more land under cultivation to create an adequate food supply. Fertilizers are available in solid, granulated, and liquid form. Versatility of application is desirable because certain environments and soil types require liquids, while in other areas solids are better. Some fertilizers are combustible and therefore must be stored with care.

F.4.2.2 Uses and Consumers of Products

Fertilizers are used to increase crop yields per acre and restore nutrients to leeched soils. The principal consumers are individual farmers, agribusinesses, and government and quasi-government agencies. Data on historical trends in production, consumption, and net exports are presented in Table F-30 in Section F.4.4.

F.4.2.3 Substitution Possibilities

The principal substitutes for synthetic fertilizers are more traditional fertilizers--manure and compost. Although these natural fertilizers excel in many soil types, their quantity is not great enough to support modern agriculture.

F.4.3 Organization of the Industry

F.4.3.1 Firm Characteristics

Large corporations dominate the small ones in terms of output share in all three industries. The staying power of large companies is attributed to their ability to gather and spend resources on research and development in a political environment that favors increased environmental regulation (Sawinski, 1995). Table F-27 provides the size of establishments and value of shipments in these industries.

The competitive nature of an industry can be broadly assessed by looking at the number of players in the industry. In 1992, 103 companies controlled 152 facilities in SIC 2875, 54 companies operated 75 facilities in SIC 2874, and 313 companies operated 401 facilities in SIC 2875. The large number of players in SIC 2875 indicates that it is a competitive industry.

Economists also estimate four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indexes (HHI) to evaluate the competitiveness of a given industry. The four-firm concentration ratio for phosphatic fertilizers in 1992 was 62, meaning that the top four firms accounted for 62 percent of the industry’s total sales. The phosphatic fertilizer industry is therefore considered to be less competitive, because a big share of the market is concentrated in the hands of a few large firms. On the other hand, the

Table F-27. Size of Establishments and Value of Shipments

Establishments With an Average of	1992 Number of Facilities	1992 Value of Shipments (1998 $\$10^6$)	1997 Number of Facilities	1997 Value of Shipments (1998 $\$10^6$)
SIC 2873 Nitrogenous Fertilizers				
1 to 4 employees	41	32.3	50	41.9
5 to 9 employees	19	34.5	21	50.0
10 to 19 employees	15	39.7	17	47.6
20 to 49 employees	32	447.5	24	498.5
50 to 99 employees	22	634.8	10	494.5
100 to 249 employees	21	2,263.2	19	D
250 to 499 employees	1	D	1	D
500 to 999 employees	1	D	1	D
Total	227	3,451.9	143	3,793.3
SIC 2874 Phosphatic Fertilizers				
1 to 4 employees	11	5.7	14	15.0
5 to 9 employees	16	37.5	8	48.8
10 to 19 employees	7	27.2	1	D
20 to 49 employees	15	719.3	9	171.3
50 to 99 employees	5	D	6	220.2
100 to 249 employees	10	648.3	12	1,233.3
250 to 499 employees	6	1,341.7	7	2,232.7
500 to 999 employees	3	1,931.7	3	D
1,000 to 2,500 employees	2	D	1	D
Total	75	4,332.8	61	5,793.9
SIC 2875 Fertilizers, Mixing Only				
1 to 4 employees	109	68.6	135	167.4
5 to 9 employees	96	216.0	94	285.9
10 to 19 employees	97	501.4	96	427.2
20 to 49 employees	69	677.7	87	1,018.7
50 to 99 employees	21	426.8	26	700.8
100 to 249 employees	9	489.6	4	271.4
250 to 499 employees	0	0.0	2	D
500 to 999 employees	0	0.0	1	D
Total	401	2,380.1	445	3,339.7

D = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990a. *1987 Census of Manufactures, Industry Series: Agricultural Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Agricultural Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999a. *1997 Census of Manufactures, Industry Series*. Washington, DC: Government Printing Office.

CR4 and CR8 for mixing-only fertilizers were 19 and 31 respectively, in 1992, indicating the presence of a competitive market.

The 1992 Department of Justice's Horizontal Merger Guidelines also provide criteria for assessing market power based on HHIs. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. In 1992, the HHI for nitrogenous fertilizers was 792, so it is a less concentrated industry (i.e., more competitive). The HHI for phosphatic fertilizers was 1,528 (moderately competitive), and mixing-only fertilizers was 187 (more competitive). Table F-28 summarizes data on various metrics for assessing the market structure of the fertilizer industries.

Table F-28. Measures of Market Concentration by SIC: 1992

	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2873	Nitrogenous Fertilizers	48	67	792	103	152
SIC 2874	Phosphatic Fertilizers	62	83	1,528	54	75
SIC 2875	Mixing Only Fertilizers	19	31	187	313	401

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Agricultural Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office

Firms in these industries are either large public or private corporations or small private companies engaged in producing other chemicals in addition to fertilizers. Many of the other products produced by these companies are classified as industrial organic or inorganic chemicals. For SIC 2873, the largest American companies are Farmland Industries ($9,800.0 million in sales), Unocal Corporation ($9,599.0 million), Land O'Lakes

Corporation ($3,013.6 million), Chevron Chemical Company ($2,872.0 million), and Terra Industries Inc. ($1,468.2 million).

For SIC 2874, the largest American manufacturers are CF Industries Inc. ($1,468.2 million), Arcadian Corporation ($1,100.3 million), Freeport-McMoran Resource Partners LP ($957.0 million), Comico Fertilizers Division ($800.0 million), and J.R. Simplot Mineral and Chemicals Division ($750.0 million).

For SIC 2875, the largest American producers are Cenex/Land O'Lakes Agricultural Services ($2,200.0 million), Scotts Company ($751.8 million), O.M. Scott and Sons Company ($466.0 million), Tennessee Farmers Cooperative ($427.7 million), and Vigoro Industries Inc., Kaiser-Etech Division ($400.0 million).

F.4.3.2 Geographical Distribution

Florida is the only state listed as a top five producer in all three industries and is the number one producer of phosphatic and mixing-only fertilizers. In SIC 2873, Florida was fifth in 1992 production, far behind Louisiana which accounted for 22.7 percent of the national total (see Table F-29). The Midwestern states of Iowa, Nebraska, and Illinois filled the gap between the two southern states.

In the phosphatic fertilizer industry, Florida accounts for nearly 60 percent of the nation's total value of shipments and employs an equal percentage of the industry's labor. North Carolina is the nation's leader in gypsum production. Although the small number of firms in the state requires that business information remain undisclosed, North Carolina is arguably the second largest producer with companies such as Union Carbide operating in Charlotte. Florida led this industry with $418.5 million in shipments in 1992, but Ohio, Texas, Washington, and California were also key states for this industry. These top five states produced 48 percent of the nation's total in 1992. These states are prime locations for the fertilizer industry because of proximity to raw material, ports, and product markets.

F.4.4 Markets and Trends

F.4.4.1 Production

Table F-30 presents the trends in production, consumption, and net exports of nitrogenous and phosphatic fertilizers between 1989 and 1995. Fertilizer production increased by 19.9 percent over this period. Consumption is estimated to be the difference between domestic production and net exports.

Table F-29. Industry Statistics for the Top Five States, 1992

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees	Number of Employees
SIC 2873 Nitrogenous Fertilizers				
Louisiana	784.9	8	1	900
Iowa	143.8	5	1	300
Nebraska	105.4	3	0	200
Illinois	90.8	7	4	200
Florida	71.0	5	2	200
USA	3,452.0	152	77	7,000
SIC 2874 Phosphatic Fertilizers				
Florida	2,748.8	15	2	5,900
North Carolina	(D)	9	7	500-999
Idaho	(D)	3	1	500-999
Louisiana	(D)	4	0	500-999
Georgia	67.6	5	2	200
USA	4,711.4	75	34	9,500
SIC 2875 Fertilizers, Mixing Only				
Florida	418.5	42	25	1,000
Ohio	254.2	31	17	900
Texas	234.8	26	21	500
Washington	138.2	16	12	300
California	107.7	25	19	500
USA	2,380.1	401	302	6,900

D = undisclosed

Source: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Agricultural Chemicals*. Washington, DC: Government Printing Office.

Domestic. Real growth in nitrogenous fertilizers is not expected to exceed 1 or 2 percent a year in the future, partly because of the difficulty in handling gaseous anhydrous ammonia. Phosphatic fertilizers are predicted to follow a similar trend (Department of Justice and Federal Trade Commission, 1992).

Foreign. The United States's decline in these industries relative to other countries is due to relatively less expensive natural gas in countries such as Russia, Canada, and Mexico

Table F-30. Production and Consumption of Fertilizers, 1989-1995 (1998 $\$10^6$)

Year	Domestic Production	Domestic Consumption	Net Exports
SIC 2873 and SIC 2874 Combined			
1989	8,248.2	6,116.4	2,131.9
1990	8,948.8	5,799.9	3,148.9
1991	9,053.4	6,762.0	2,291.4
1992	8,163.4	6,601.9	1,561.5
1993	7,629.4	6,897.3	732.1
1994	9,146.6	7,680.8	1,465.7
1995	9,893.7	8,062.1	1,831.6

Note: Consumption = Domestic Production - Exports + Imports

Sources: U.S. Department of Commerce, International Trade Administration. 1990. *1990 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1991. *1991 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Agricultural Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

DRI McGraw Hill, Standard and Poor's and U.S. Department of Commerce, International Trade Administration. 1998. *U.S. Industry and Trade Outlook 1998*. New York: McGraw Hill.

for producing nitrogenous fertilizers. For phosphatic fertilizers, the emergence of Morocco as a significant producer will impact the United States's export markets. Morocco has four times the phosphatic ore deposits of the Unites States. The United States imported $1.4 billion worth of fertilizers in 1996, leaving net exports of $1.7 billion.

F.4.4.2 Consumption

Domestic. Domestic consumption of fertilizers is not expected to exceed the 1 to 2 percent growth in production in the foreseeable future.

Foreign. The U.S. net exports of fertilizers in 1995 were valued at $1,831.6 million. The largest export markets are in South and East Asia. Foreign consumption of fertilizers produced by the United States has declined because of an oversupply caused by Morocco flooding the fertilizer market in attempts to gain foreign exchange.

F.5 Photographic Equipment and Supplies

All photographic chemicals, equipment, and supplies are classified under SIC 3861, photographic equipment. Establishments are divided into two groups, photographic apparatus and sensitized film and chemicals. Photographic apparatus include all cameras, both still and motion picture; tripods; editing equipment; photocopiers; and projectors. This industry profile focuses on photographic film, plates, and the chemicals used in the photographic process. In 1997, the Census Bureau began reporting industry statistics based on the new North American Industry Classification System (NAICS). Under the new NAICS system, the two sectors of SIC-coded industry 3861 are now separated into industry 333315, photographic and photocopying equipment manufacturing and industry 325992, photographic film, paper, plate, and chemical manufacturing.

Shipments of photographic equipment declined 7.5 percent between 1987 and 1997. The overall photographic equipment industry (SIC 3861) grew through 1989. Subsequently, increased foreign competition and the early 1990s recession brought down the value of shipments. The industry went from a high of $24,919.4 million in 1989 to a low of $21,403.5 million in 1997 (see Table F-31). All values in this report are presented in 1998 dollars.[2]

Value of shipments for subsectors SIC 38615 (photographic sensitized film and plates; silver halide type), and SIC 38617 (sensitized photographic paper and cloth; silver halide type) declined over the period 1987 to 1995. Although the American photographic equipment industry has been experiencing a downward trend since 1990, the prepared photographic chemicals subsector (SIC 38618) has fared well. SIC 38618 contributed 12.7 percent to the total value of shipments for SIC 2861 in 1995, up from a 6.6 percent contribution in 1987. Increased sales of photographic still camera film is attributed to new disposable cameras that are essentially film surrounded by a recyclable body with buttons, lenses, and a flash. New products such as these are spurring the demand for other complementary products.

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[2]Values adjusted using the plant cost index published in *Chemical Engineering*, various years.

Table F-31. Value of Shipments, Photographic Equipment, 1987 to 1997 (1998 $\$10^6$)

Year	SIC 3861	SIC 38615	SIC 39617	SIC 38618
1987	23,144.5	5,467.5	1,501.0	1,473.4
1988	23,365.3	5,607.0	1,487.7	1,589.3
1989	24,919.4	5,587.0	1,513.4	1,485.0
1990	22,893.0	5,612.5	1,543.9	1,624.7
1991	23,067.7	5,701.4	1,381.4	1,762.8
1992	24,085.3	6,090.2	1,451.7	2,014.4
1993	24,198.7	5,750.2	1,633.8	2,440.5
1994	24,613.8	5,849.3	1,503.4	2,672.6
1995	22,059.5	5,781.4	1,495.5	2,808.7
1996	22,752.2	NA	NA	NA
1997	21,403.5	NA	NA	NA

NA = not available

Sources: U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Census of Manufactures, Industries Series: Medical Instruments; Opthalmic Goods; Photographic Equipment; Clocks, Watches, and Watchcases*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999c. *1997 Census of Manufactures, Industries Series: Photographic Film, Paper, Plate and Chemical Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999c. *1997 Census of Manufactures, Industries Series: Photographic and Photcopying Equipment*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

The United States consumes 40 percent of the world's photographic chemicals and equipment, followed by Japan (27.8 percent), Western Europe (10.9 percent; excluding Germany), Germany (6.6 percent), Eastern Europe (10.3 percent), and Africa and Asia combined (2.8 percent) (see Figure F-2).

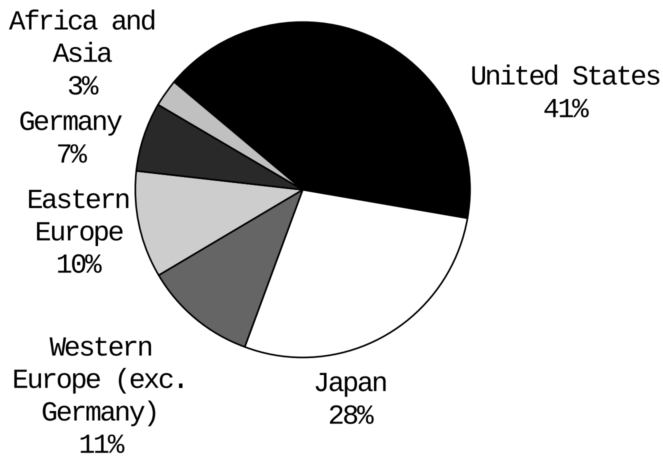

Figure F-2. Worldwide Photographic Equipment and Supplies Consumption by Country

F.5.1 Supply Side of the Industry

F.5.1.1 Production Processes

Photographic materials are produced by coating film, plates, or paper with chemicals that hold latent images after exposure. The process begins with the growth of silver halide crystals, often in vessels as large as 2,000 liters in large commercial facilities. Silver ions from a silver nitrate solution and halide ions from alkali halide salt solution come together to form the silver halide. The crystals are suspended in a gelatin then washed to remove unwanted elements. Next, the silver halide is once again suspended in a gelatin, but it is cooled soon thereafter to form a gel. The silver halide is kept in gel form until further processing.

Once the manufacturer decides to take the process to the next step, the emulsion is melted and dyes may be added to increase sensitivity for one spectrum or another. After further sensitivization, the material is coated onto a support, usually paper, glass, film, or plates. Antifoggants, dye-release materials (for color film), and hardeners are added beforehand. Once the support is coated, the photographic materials are ready to be exposed.

The chemicals used to develop these photographic materials and toners are produced by mixing intermediate chemicals with necessary additives. The process depends on which of the over 60 chemicals is used in photographic materials development.

F.5.1.2 Major By-products and Co-products

The industry is inventing new techniques for reusing the film canisters and collecting and reusing the silver and gold used in production and from post-consumer products. The drying and disposal of photochemicals during the production and development of the product are on-going concerns.

F.5.1.3 Types of Output

SIC 3861 produces the following relevant products: sensitized blueprint cloth and paper; sensitized brownprint cloth and paper; sensitized diazo cloth and paper; sensitized motion-picture, x-ray, still camera, and special purpose films; sensitized graphic arts plates; heat sensitized paper made from purchased paper; sensitized latern slide plates; photographic metallic emulsion sensitized paper and cloth; packaged photographic chemicals; sensitized photographic paper and cloth; sensitized photographic plates; prepared and packaged photographic toners; and x-ray plates.

F.5.1.4 Costs of Production

The photographic equipment and supplies industry has invested heavily in new capital equipment to increase production efficiency. The early 1980s saw the industry employing over 100,000 employees. By 1997, that figure had dropped to 63,700. Table F-32 depicts the decline in the number of workers employed by the industry over the period 1987 to 1997. Most jobs lost have been at the production and distribution level. Total employment and payroll decreased approximately 28 and 15 percent, respectively. The cost of materials stayed fairly constant from 1987 to 1995 but rose to a new high of $8,143.0 million dollars in 1997. New capital investment averaged $924.0 million a year and energy costs averaged $203.3 million a year during this period.

Table F-32. Inputs: Photographic Equipment and Supplies

Year	Labor Quantity (10^3)	Labor Payroll (1998 $\$10^6$)	Materials (1998 $\$10^6$)	New Capital Investment (1998 $\$10^6$)	Energy (1998 $\$10^6$)
1987	88.0	3,462.3	7,498.3	819.2	203.6
1988	87.5	3,370.0	7,548.9	920.8	199.0
1989	87.0	3,435.0	7,600.8	1,104.9	204.7
1990	79.3	3,199.4	7,013.6	1,098.6	208.3
1991	78.0	3,281.6	7,208.2	1,174.2	204.6
1992	77.5	3,337.5	7,675.5	878.7	215.2
1993	75.7	3,124.0	7,320.1	840.9	210.1
1994	63.9	2,837.1	7,385.6	796.7	211.8
1995	61.1	2,780.3	7,298.0	762.6	189.3
1996	60.7	2,855.2	8,280.0	738.9	199.9
1997	63.7	2,960.8	8,934.4	NA	189.6

Sources: U.S. Department of Commerce, Bureau of the Census. 1990g. *1988 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992a. *1990 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Census of Manufactures, Industry Series: Medical Instruments; Opthalmic Goods; Photographic Equipment; Clocks, Watches, and Watchcases*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999c. *1997 Census of Manufactures, Industries Series: Photographic Film, Paper, Plate and Chemical Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999d. *1997 Census of Manufactures, Industries Series: Photographic and Photcopying Equipment*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

F.5.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. Table F-33 presents the historical trends in the capacity utilization for the photographic equipment and supplies industry. The full capacity utilization ratio for the photographic equipment and supplies industry was 83 in 1997, indicating that plants in this industry are operating near full capacity but have room to increase their production

Table F-33. Capacity Utilization Ratios for SIC 3861

	1992	1993	1994	1995	1996	1997
SIC 3861	88	85	92	83	82	83

Source: U.S. Department of Commerce, Bureau of the Census. 1996. *Survey of Plant Capacity: 1994.* Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999i. *Survey of Plant Capacity: 1997.* Washington, DC: Government Printing Office.

F.5.2 Demand Side of the Industry

F.5.2.1 Product Characteristics

Photographic films, plates, and papers are available in different forms: disc format, cassettes, reels, 35 mm, 70 mm, and a variety of others. They can hold both color and black and white latent images.

Photochemicals and toners are used to develop the latent images captured by the photographic material and to enhance certain characteristics, such as color and texture.

F.5.2.2 Uses and Consumers of Products

The largest consumer group of photographic films is individual consumers. Photographic materials are used to capture images from holidays, ceremonies, vacations, religious days, national days, and other events deemed significant by the end user.

The motion picture and television industries of New York and California are the largest consumers of motion picture film. These films are used in the production of programs to be viewed in cinemas and on television.

Other significant user groups include photographers, hospitals (x-ray plates), commercial outfits, publishers, and all levels government agencies. Chemicals and toners are consumed predominantly by those who develop photographic materials. Table F-37 in Section F.5.4 presents data on historical trends in consumption of photographic products.

F.5.2.3 Substitution Possibilities

For years, the only substitute for photographic products was videotape. However, many companies are currently developing products that capture images digitally. To date, digital products do not have the same quality and clarity as chemical products. But the medical industry is leading the push towards digital photography because of its advantages in storage, archiving, and electronic transport from one hospital to another.

F.5.3 Organization of the Industry

F.5.3.1 Firm Characteristics

Most firms in this industry are small and are involved in small-scale, specialized product production. Market-leaders are large, multinational firms that have just emerged from a period of corporate austerity and are streamlined and more efficient. In the early 1990s, many firms spun off subsidiaries and maneuvered themselves to become more vertically integrated (U.S. Department of Commerce, International Trade Administration, 1993). Eight hundred thirty-one companies controlled 904 facilities by 1992. In 1997, 694 firms controlled 738 facilities.

As Table F-34 shows, in both 1992 and 1997, firms with more than 100 employees dominated the market (in terms of value of shipments). This is not surprising because of the presence of the three largest companies in the photographic supplies and chemicals industry in America: Eastman Kodak, Polaroid, and DuPont. Establishments with more than 100 employees accounted for 86 percent of the industry’s total value of shipments in 1992 and 90 percent of the industry’s total value of shipments in 1997.

Table F-34. Size of Establishments and Value of Shipments, SIC 3861

Establishments With an Average of	1992 Number of Facilities	1992 Value of Shipments (1998 $\$10^6$)	1997 Number of Facilities	1997 Value of Shipments (1998 $\$10^6$)
1 to 4 employees	324	92.6	295	77.7
5 to 9 employees	178	162.0	100	86.5
10 to 19 employees	138	294.8	105	209.1
20 to 49 employees	122	579.7	112	594.0
50 to 99 employees	54	778.2	61	857.5
100 to 249 employees	56	1,563.8	32	1,119.5
250 to 499 employees	16	1,719.6	19	D
500 to 999 employees	7	18,894.6	8	D
1,000 to 2,499 employees	5	D	3	D
2,500 or more employees	4	D	3	D
Total	904	24,085.3	738	21,403.5

D = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990c. *1987 Census of Manufactures, Industry Series, Medical Instruments; Opthalmic Goods; Photographic Equipment; Clocks, Watches, and Watchcases*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Census of Manufactures, Industry Series: Medical Instruments; Opthalmic Goods; Photographic Equipment; Clocks, Watches, and Watchcases*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999c. *1997 Census of Manufactures, Industries Series: Photographic Film, Paper, Plate and Chemical Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999d. *1997 Census of Manufactures, Industries Series: Photographic and Photcopying Equipment*. Washington, DC: Government Printing Office.

The largest American firms in SIC 3861 are Xerox Corporation ($16,611.0 million in sales in 1992), Eastman Kodak Company ($14,980.0 million), Polaroid Corporation ($2,275.2 million), and Imation Corporation ($2,245.2 million).

To assess the competitiveness of a market, economists often estimate four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indexes (HHI). The CR4 for photographic equipment in 1992 was 78, meaning that the top four firms accounted for 78 percent of the industry's total sales. The CR8 for the same year was 83 (U.S. Department of Commerce, 1995a). These high concentration ratios indicate that market share is concentrated in the hands of a few companies. The 1992 Department of Justice's Horizontal Merger Guidelines also provide criteria for evaluating the degree of competitiveness in a given industry based on HHIs. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive) (U.S. Department of Justice, 1992). Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. The HHI for photographic equipment was 2,408, more concentrated (i.e., less competitive) (U.S. Department of Commerce, 1995a). Table F-35 summarizes the various criteria for assessing the market structure of the photographic industry.

Table F-35. Measures of Market Concentration for SIC 3861: 1992

	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 3861	Photographic Equipment	78	83	2,408	831	904

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Census of Manufacturers, Industry Series: Medical Instruments; Opthalmic Goods; Photographic Equipment; Clocks; Watches, and Watchcases*. Washington, DC: Government Printing Office.

F.5.3.2 Geographic Distribution

It is generally accepted that New York is the U.S. leader in value of shipments and employment (see Table F-36). However, value of shipments data were withheld to prevent the disclosure of confidential business information.

Table F-36. Industry Statistics for the Top Five States for SIC 3861, 1992

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees	Number of Employees
New York	(D)	112	72	25,000 to 49,999
Massachusetts	2,021.0	50	21	7,800
California	807.9	142	103	6,800
New Jersey	801.1	67	48	2,900
Illinois	505.5	76	51	3,000
Pennsylvania	413.5	40	27	1,400
USA	24,085.3	904	640	39,400

D = undisclosed

Source: U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Census of Manufactures, Industry Series: Medical Instruments; Opthalmic Goods; Photographic Equipment; Clocks, Watches, and Watchcases*. Washington, DC, Government Printing Office.

Massachusetts has long been one of the main states in this industry because of the presence of Polaroid. The photographic industry in California has experienced high growth, largely because of the presence of the motion picture industry and the state's proximity to the emerging markets of Asia and Oceana.

F.5.4 Markets and Trends

F.5.4.1 Production

Table F-37 depicts the trends in consumption and production for this industry, inclusive of international trade. From 1987 to 1994, net imports of photographic equipment and supplies increased 27.6 percent. Imports supplied a greater fraction of the domestic market. Domestic production of these products decreased by 7.16 percent, outpacing the 3.8 percent decline in domestic consumption.

Table F-37. Production and Consumption of Photographic Materials[a] (1998 $$10^6$)

Year	Domestic Production	Domestic Consumption	Net Exports
1987	24,441.1	27,030.8	–2,589.7
1988	24,755.3	27,686.7	–2,931.5
1989	26,589.8	29,527.3	–2,937.5
1990	24,270.5	26,547.5	–2,277.1
1991	23,561.7	25,784.3	–2,223.2
1992	24,085.3	26,954.9	–2,869.6
1993	23,579.3	26,714.3	–3,135.0
1994	23,377.0	26,780.0	–3,403.0

Note: Consumption = Domestic Production **-** Exports + Imports

[a]Numbers do not add up because of rounding.

Sources: U.S. Department of Commerce, International Trade Administration. 1989. *1989 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Census of Manufactures, Industry Series: Medical Instruments; Opthalmic Goods; Photographic Equipment; Clocks, Watches, and Watchcases*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1993. *1994 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

DRI McGraw Hill, Standard and Poor's, and U.S. Department of Commerce, International Trade Administration. 1998. *U.S. Industry and Trade Outlook 1998*. New York: McGraw Hill.

Domestic. The United States is the largest producer of photographic chemicals and equipment in the world. Increasingly, Southeast Asia dominates still-camera hardware production. The United States has not, however, relinquished its control as the world market leader in photographic chemicals and films, plates, and papers production. Film, papers, and chemicals production is projected to increase an average of 2 percent a year through the end of the century.

Foreign. Seventy-one percent of the United States' imports come from Asia, 62 percent of which are from Japan. Nearly all imports from Asia are produced by Japanese companies either in Japan proper or from overseas production facilities in Hong Kong, the Philippines, China, and ROC on Taiwan.

F.5.4.2 Consumption

Domestic. Domestic consumption patterns are serviced by both American and foreign firms, mostly Japanese. In 1996, the U.S. trade deficit in this product category widened to $4,600 million, upon receipt of nearly $10,900 million in imports (all in actual dollars).

Foreign. The largest foreign markets for U.S. photographic chemicals and films, paper, and plates are Europe, Asia, NAFTA members, and Latin America. In 1994, the United States exported $5,900 million worth of product (see Figure F-3).

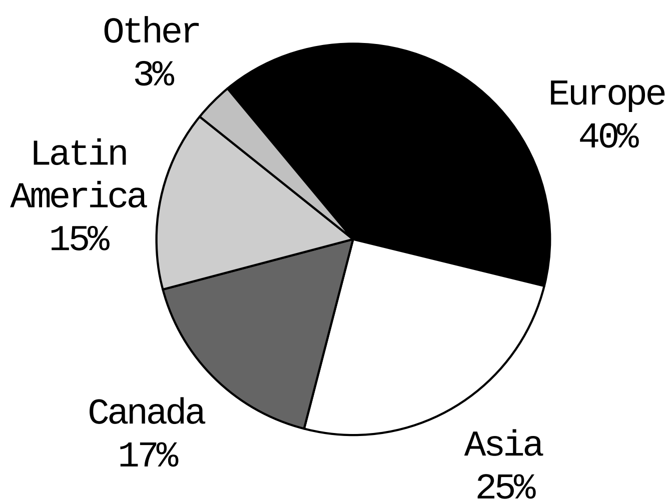

Figure F-3. U.S. SIC 3861 Export Markets, 1994

F.6 Adhesives, Sealants, and Printing Ink

SIC 289 is reserved for industries that produce chemicals and allied products that are not classified in any of the other chemical subcategories (SIC 28). In 1995, adhesives and sealants (SIC 2891), printing ink (SIC 2893), and chemical preparations (SIC 2899) accounted for only 7 percent of the chemical industry shipments. Still they provide the U.S. economy with important products for automobiles and publishing houses, for instance. As shown in Table F-38, shipments were valued at $25,382.2 million in 1997. All dollar values used in the subsequent analysis are 1998 dollars unless otherwise noted.[3]

Table F-38. Value of Shipments (1998 $$10^6$)

Year	SIC 2891 Adhesives and Sealants	SIC 2893 Printing Ink	SIC 2899 Chemical Preparations
1987	5,627.3	2,877.0	9,653.3
1988	5,526.7	2,783.0	9,924.1
1989	5,792.8	2,890.2	9,686.3
1990	5,974.4	3,000.1	10,258.2
1991	5,997.2	3,046.2	9,892.1
1992	6,153.5	3,343.8	10,836.6
1993	6,370.1	3,486.4	11,861.9
1994	6,045.6	3,608.9	11,965.2
1995	5,930.7	3,803.0	13,435.5
1996	6,597.6	4,104.8	12,114.8
1997	7,387.9	4,172.4	13,821.9[a]

[a] Excludes 7 firms which produce chemical preparations, not elsewhere classified

Sources: U.S. Department of Commerce, Bureau of the Census. 1995e. *1992 Census of Manufactures, Industry Series: Miscellaneous Chemical Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

[3]Values adjusted using the plant cost index published in *Chemical Engineering*, various years.

The adhesives and sealants industry (SIC 2891, NAICS 325520) comprises establishments engaged in manufacturing adhesives for industrial and manufacturing uses. The industry has experienced an increase of 31 percent in the value of shipments from 1997 to 1987. Most of the increase is due to a sharp 12 percent rise in shipments between 1996 and 1997.

The printing ink industry (SIC 2893, NAICS 325910) comprises establishments engaged in manufacturing printing inks such as gravure ink, screen process ink, and lithographic ink. The value of industry shipments grew 45 percent between 1987 and 1997, despite the recession of the early 1990s. In 1997, the industry's shipments were valued at $4172.4 million.

The chemical preparations industry (SIC Code 2899) shipped $13,821.9 million worth of product, more product(in terms of dollar value) than the adhesives and sealants and printing ink industries combined. This industry is diverse, with a wide range of products, including bluing, writing ink, industrial compounds, and fatty acids. The industry has recently been broken up into four groups and combined with other industries in the North American Industry Classification System (NAICS). Because of the broad nature of the chemical preparation industry, it has been omitted from later sections of this profile.

NAICS codes partially composed of segments of the old chemical preparations industry (SIC code 2899) include paint and coating manufacturing (NAICS code 32551); spice and extract manufacturing (NAICS code 311942); all other basic organic chemical manufacturing (NAICS code 325199); and all other miscellaneous chemical products and preparation manufacturing (NAICS code 325998).

F.6.1 Supply Side of the Industry

F.6.1.1 Production Processes

Adhesives and Sealants. The manufacturing process for adhesives and sealants involves combining raw materials in the production apparatus. After the mixing and heating processes have been completed, the mixture is prepared for packaging. Colorants and other additives are added to the mixture during the later stages of production.

Printing Ink. To manufacture ink, the producer subjects dry components to two general processes: mixing and milling. Mixing involves wetting the dry pigments and additives with a liquid vehicle (resins and solvents), until there is no discernible dry pigment remaining. Ideally, a finished ink is produced during this stage or after subsequent dilution. Milling can be used to break components down further to create a finer solution, if desired. The most important aspect of ink manufacture is the proper dispersion of pigments in the vehicle. For liquid inks, the paste is placed into a dissolver and more resins and solvents are added to create an ink with the desired consistency.

F.6.1.2 Major By-products and Co-products

There are no significant by- or co-products generated during the manufacture of adhesives and sealants or printing ink.

F.6.1.3 Types of Output

The adhesives and sealants industry produces the following products: adhesives, caulking compounds, both linoleum and mending cements, epoxy adhesives, all glues (except dental), household iron cement, joint compounds, laminating compounds, mucilage, adhesive paste, household porcelain cement, sealing compounds for pipe threads and joints as well as for synthetic rubber and plastics, and sealing wax.

The printing ink industry produces lithographic inks, screen process ink, bronze ink, flexographic ink, gold ink, duplicating ink, letterpress ink, offset ink, base and finished printing ink, and gravure ink. Writing and drawing inks are not included in this classification.

F.6.1.4 Costs of Production

As Table F-39 suggests, the adhesives and sealants industry was seemingly stagnant over the period 1987 to 1992. However, growth in the industry has since been spurred by product innovations and new applications or the adaptation of adhesives and sealants to existing manufacturing technologies. Investment in research and development and falling labor costs due to increased mechanization have allowed the industry to become more efficient. Most of the 3,600 jobs eliminated from the industry from 1987 to 1996 have been at the production level. There was substantial growth in the industry between 1996 and 1997, which was accompanied by a 20 percent increase in employment (20 percent) between 1996 and 1997. Over 1987 to 1997, the cost of materials fell by 18 percent.

Adhesives and sealants manufacturers are counting on proactive research and development to keep them one step ahead of environmental regulators and market demands. In particular, the Clean Air Act motivates them to develop new products (Tollefson, 1994).

Table F-39. Inputs: Adhesives, Sealants, and Printing Ink

Year	Labor: Quantity (10^3)	Labor: Payroll (1998 $\$10^6$)	Materials (1998 $\$10^6$)	New Capital Investment (1998 $\$10^6$)	Energy (1998 $\$10^6$)
SIC 2891 Adhesives and Sealants					
1987	20.9	664.9	3,241.6	134.4	69.2
1988	21.2	658.5	3,270.2	134.6	67.7
1989	21.9	671.5	3,429.0	149.3	67.4
1990	21.4	689.8	3,450.5	138.5	68.8
1991	20.9	695.9	3,429.6	150.2	69.4
1992	21.1	737.0	3,280.5	206.2	75.9
1993	20.9	744.9	3,389.5	202.7	76.5
1994	19.2	727.3	3,538.3	216.1	72.9
1995	18.8	658.9	3,582.3	201.3	66.0
1996	17.3	670.6	3,909.8	192.0	71.6
1997	21.7	833.6	3,982.1	NA	89.2
SIC 2893 Printing Ink					
1987	11.1	371.6	1,695.8	45.5	23.8
1988	11.1	382.9	1,719.3	39.2	24.5
1989	11.3	391.0	1,756.2	51.0	26.5
1990	11.4	386.0	1,932.2	48.2	26.6
1991	10.8	386.1	1,899.2	31.5	26.5
1992	12.3	439.4	2,145.4	50.0	27.8
1993	12.0	438.2	2,261.9	60.5	27.5
1994	13.3	485.0	2,277.6	58.6	30.5
1995	14.2	517.7	2,228.0	59.3	29.9
1996	13.1	502.4	2,347.6	84.4	30.4
1997	13.0	505.4	2,513.0	NA	27.6

[a]Excludes seven firms for which data are undisclosed.

Sources: U.S. Department of Commerce, Bureau of the Census. 1990g. *1988 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992a. *1990 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995e. *1992 Census of Manufactures, Industry Series: Miscellaneous Chemical Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

Unlike the adhesives and sealants industry, the printing ink industry's growth has been matched by an equivalent growth in input costs. From 1987 to 1997, the printing industry's value of shipments increased 45 percent in real terms. Accompanying this increase, payroll costs have risen by 36 percent, materials by 48 percent, and energy by 16 percent (see Table F-39). The industry anticipated the rising costs of raw materials and labor. However, environmental initiatives are a growing concern, specifically those pertaining to air permit compliance for volatile organic compounds (VOCs) and hazardous air pollutants (HAPs).

F.6.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. Table F-40 presents the historical trends in the capacity utilization for the adhesives and sealants (SIC 2891) and the printing ink (SIC 2893) industries. The data indicate that plants in SIC 2891 and SIC 2893 have been operating below full capacity.

Table F-40. Capacity Utilization Ratios for SICs 2891 and 2893

	1992	1993	1994	1995	1996	1997
SIC 2891	75	78	82	71	71	67
SIC 2893	79	79	77	64	72	66

Source: U.S. Department of Commerce, Bureau of the Census. 1996. *Survey of Plant Capacity: 1994*. Washington, DC: Government Printing Office.

F.6.2 Demand Side of the Industry

F.6.2.1 Product Characteristics

Adhesives and sealants are as varied as printing inks in terms of viscosity and physical characteristics. Those differences aside, all adhesives help to distribute pressure and stress over a wide area and resist vibration, in addition to joining two surfaces. Sealants prevent the passage of air, water, or chemicals between two surfaces. Sealants, however, do not have the same cohesive power as adhesives.

The adhesives and sealants industry is in a state of transition; products are being reformulated to better serve consumers and adjust to current and pending environmental regulations. The industry is developing products that have built-in primers. Primers are used because they help create the best possible adhesion to a surface, but they are flammable and highly volatile. Another change is the reduction in solvents used because of environmental regulations on chloroflourocarbons, VOCs, and other ecological considerations. Solvents emit VOCs when they dry. The industry is researching how to create durable and water-resistant products without using solvents. Currently, many industrial adhesives are 100 percent solids, epoxies, and urethane.

Printing inks are available in two forms, pastes and liquids. Although all inks share the ability to be applied to a variety of surfaces, inks differ in their viscosity, composition, method of drying, and physical appearance. These differences are largely the result of differing applications and uses. However, they all color a surface to produce a desired effect. In the 1990s, inks became increasingly water-based, a shift away from the traditional resins and solvent-based inks.

F.6.2.2 Uses and Consumers of Products

Adhesives and sealants are used by individual consumers and the construction, packaging, furniture, appliance, textile, aircraft, and other industries. Technological advances have contributed to their use by the automotive industry to help build lighter and more fuel-efficient cars. Adhesives have replaced metal fasteners and spot welds because adhesives do not suffer from the same traditional bonding corrosion that metals often do. Automotive applications of adhesives have experienced the largest growth rates.

Printing inks are used by publishing, printing, and copy houses and are the most essential input in that process. Writing and drawing inks are not included in this SIC code. Common consumers include publishers, newspapers, copy centers, and the technology industry.

Table F-44 in Section F.6.4 presents statistics on production, consumption, and net exports for the adhesives and sealants, and printing ink industries.

F.6.2.3 Substitution Possibilities

Substitutes for adhesives and sealants vary depending on their use. For instance, in the automotive industry, two steel surfaces can be welded together rather than attached using an adhesive.

Currently, there are no substitutes for printing inks. However, within the industry, powders, pastes, and liquids are interchangeable, depending on the nature of their application.

F.6.3 Organization of the Industry

F.6.3.1 Firm Characteristics

The number of companies in the adhesives and sealants industry (SIC 2891) decreased from 537 to 517 over the 1987 to 1992 period (U.S. Department of Commerce, 1995e; U.S. Department of Commerce, 1990d). The number of facilities in this industry also decreased from 714 to 685 during the same period.

For SIC 2891, the largest producers in the United States are Illinois Tool Works Inc. ($4,996.7 million in sales), Borden Inc. ($3,861.0 million), Morton International Inc. ($3,612.5 million), Avery Dennison Corporation ($3,222.5 million), and Sonoco Products Inc. ($2,706.0 million).

The number of companies in the printing ink industry (SIC 2893) decreased from 224 to 220, while the number of facilities increased from 504 to 519 between 1987 and 1992. The printing ink industry is dominated by medium-sized firms. Firms with between 20 and 250 employees accounted for 71.25 percent of all shipments in 1987. This percentage increased to 77.2 percent in 1992. However, most facilities have fewer than 50 employees (see Table F-41).

For SIC 2893, the largest producers in the United States are Sun Chemical Corporation ($2,500 million), BASF Corporation Coatings and Colorants Division ($982.0 million), Sun Chemical Corporation General Printing Ink Division ($845.0 million), Flint Ink Corporation ($600.0 million), and Inx International Ink Co. ($252.0 million).

Most facilities are located in states with significant publishing and printing sectors for printing ink and near key durable goods production centers for adhesives and sealants.

Measures of market concentration are often used as empirical guides to assess the competitiveness of a market. Typical measures include four- and eight-firm concentration

Table F-41. Size of Establishments and Value of Shipments

Establishments With an Average of	1987 Number of Facilities	1987 Value of Shipments (1998 $\$10^6$)	1992 Number of Facilities	1992 Value of Shipments (1998 $\$10^6$)
SIC 2891 Adhesives and Sealants				
1 to 4 employees	166	87.6	183	92.9
5 to 9 employees	143	312.6	122	205.9
10 to 19 employees	131	507.8	109	426.6
20 to 49 employees	163	1,569.7	162	1,708.2
50 to 99 employees	64	1,444.3	68	1,531.0
100 to 249 employees	39	1,478.5	33	1,570.5
250 to 499 employees	7	542.1	6	673.9
500 to 999 employees	1	D	2	D
Total	714	5,942.7	685	6,209.1
SIC 2893 Printing Ink				
1 to 4 employees	77	71.9	60	49.8
5 to 9 employees	102	194.6	96	186.7
10 to 19 employees	140	606.9	149	533.6
20 to 49 employees	140	1,098.0	155	1,431.7
50 to 99 employees	31	592.2	49	802.3
100 to 249 employees	14	474.6	10	369.8
Total	504	3,038.2	519	3,373.9

D = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. January 1990d. *1987 Census of Manufactures, Industry Series: Miscellaneous Chemical Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1993a. *1992 Census of Manufactures, Industry Series: Miscellaneous Chemical Products*. Washington, DC: Government Printing Office.

ratios (CR4 and CR8) and Herfindahl-Hirschmann indices (HHI). The CR4 for adhesives and sealants in 1992 was 25, meaning that the top four firms accounted for 25 percent of the industry's total sales. The CR8 for the same year was 37 (U.S. Department of Commerce, 1995a). For printing ink, the CR4 was 45 and the CR8 57. Therefore, the adhesives and sealants market is more competitive than the printing and ink market. The 1992 Department of Justice's (1992) Horizontal Merger Guidelines also provide criteria for evaluating market structure based on HHIs. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive) (U.S. Department of Justice, 1992). The HHI for adhesives and sealants was 245, less concentrated (i.e., more competitive). The HHI for printing ink was 688 (more competitive). Table F-42 summarizes the various measures of market concentration for the adhesives and sealants and the printing ink industries.

Table F-42. Measures of Market Concentration by SIC: 1992

	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2891	Adhesives and Sealants	25	37	245	517	685
SIC 2893	Printing Ink	45	57	688	220	519

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995e. *1992 Census of Manufactures, Industry Series: Miscellaneous Chemical Products*. Washington, DC: Government Printing Office.

F.6.3.2 Geographical Distribution

The adhesives and sealants industry is concentrated in Ohio (14.44 percent) (see Table F-43). Illinois, New Jersey, California, and Kentucky join Ohio in controlling 47.3 percent of the industry nationwide. The concentration of the industry is not surprising because those states' respective regions are intimately involved in durable goods manufacturing.

The top five producers of printing ink are Illinois, California, Indiana, Ohio, and North Carolina. These top five states are responsible for 38.2 percent of the nation's total value of shipments, or $1,275.9 out of $3,343.8.

Table F-43. Industry Statistics for the Top Ten States, 1992

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees)	Number of Employees
SIC 2891 Adhesives and Sealants				
Ohio	888.6	53	26	3,100
Illinois	651.2	48	25	1,700
New Jersey	496.9	53	28	1,500
California	435.9	75	45	2,100
Kentucky	435.7	9	3	800
USA	6,153.5	685	414	21,100
SIC 2893 Printing Ink				
Illinois	410.9	47	24	1,500
California	292.1	50	23	1,300
Indiana	226.4	7	2	300
Ohio	215.1	42	24	900
North Carolina	131.4	21	12	600
USA	3,343.8	519	305	12,300

Source: U.S. Department of Commerce, Bureau of the Census. 1995e. *1992 Census of Manufactures, Industry Series: Miscellaneous Chemical Products*. Washington, DC: Government Printing Office.

F.6.4 Markets and Trends

Table F-44 presents data on historical trends in production, consumption, and net exports for the adhesives and sealants, and printing ink industries. In the adhesives and sealants industry, production (as measured by value of shipments) declined by 0.5 percent, while consumption fell by 2.8 percent during the period 1987 to 1994. There was an accompanying increase (445.9 percent) in net exports of adhesives and sealants during the same period.

Reliable net export statistics are unavailable for the printing ink industry for the period prior to 1990. Data for subsequent periods indicate the increase in foreign competition faced by the printing ink industry. Domestic production grew by 17.3 percent and consumption grew by 20.9 percent between 1990 and 1995. Domestic printing ink

Table F-44. Domestic Consumption, Production and Net Exports (1998 $\$10^6$)

Year	Domestic Production	Domestic Consumption	Net Exports
SIC 2891 Adhesives and Sealants			
1987	5,942.6	5,913.1	29.4
1988	5,855.6	5,771.8	83.8
1989	6,181.1	6,119.1	62.0
1990	6,333.8	6,254.0	79.9
1991	6,125.6	6,043.0	82.5
1992	6,153.5	6,055.6	97.9
1993	6,296.3	6,159.1	137.2
1994	5,909.8	5,744.3	165.6
SIC 2893 Printing Ink			
1990	3,355.9	3,321.2	34.7
1991	3,227.4	3,193.3	34.1
1992	3,508.3	3,481.6	26.7
1993	3,724.6	3,699.9	24.8
1994	3,780.5	3,778.5	2.0

Notes: Consumption = Domestic Production - Exports + Imports
Reliable net export data are not available for the printing ink industry for the period prior to 1990.

Sources: U.S. Department of Commerce, International Trade Administration. 1989. *1989 U.S. Industrial Outlook*. Washington, DC, Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1991. *U.S. Merchandise Trade: Exports, General Imports, and Imports for Consumption 1990*. FT925/90-A. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992b. *U.S. Merchandise Trade: Exports, General Imports, and Imports for Consumption 1991*. FT925/91-A. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1993b. *U.S. Merchandise Trade: Exports, General Imports, and Imports for Consumption 1992*. FT925/9F-A. Washington, DC: Government Printing Office.

Table F-44. Domestic Consumption, Production and Net Exports (1998 $$10^6$) (continued)

Sources: U.S. Department of Commerce, Bureau of the Census. 1995e. *1992 Census of Manufactures, Industry Series: Miscellaneous Chemical Products*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1994. *U.S. Merchandise Trade: Exports, General Imports, and Imports for Consumption 1993*. FT925/93-A. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1993. *1994 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995j. *U.S. Merchandise Trade: Exports, General Imports, and Imports for Consumption 1994*. FT925/94-A. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

DRI McGraw Hill, Standard and Poor's and U.S. Department of Commerce, International Trade Administration. 1998. *U.S. Industry and Trade Outlook 1998*. New York: McGraw Hill.

demand was increasingly supplied by foreign producers, especially those from East Asia. The United States moved from being a net exporter in 1990 to a net importer by 1995, because of a major import surge.

F.6.4.1 Production

Domestic. In 1997 the adhesives and sealants industry was valued at $25 billion (1997 dollars) and is expected to grow at 3.0 percent for the next few years. But growth as high as 10 percent is expected by *Chemical Marketing Reporter Magazine* for some niche markets (Tollefson, 1994).

The printing ink industry is not anticipating any further growth until publishing houses recover from the recessionary effects of the 1995 paper price increases.

Foreign. Adhesives and sealants imports were valued at $112.0 million in 1996 (actual dollars). Most of these imports came from the European Union and NAFTA countries.

In 1996, the United States imported \$272.7 million (actual dollars) worth of printing inks, the bulk of which came from Asia and Europe (DRI McGraw Hill, 1998).

F.6.4.2 Consumption

Domestic. Domestic adhesives and sealants' demand is projected to match production and imports. Certain sectors, like the automotive and dental industries, will demand a larger quantity than they currently do. U.S. consumption of printing inks is not expected to increase in the coming years (DRI McGraw Hill, 1998).

Foreign. Total global demand for adhesives and sealants was estimated to reach 1.3 million tons annually by the year 2000 (DRI McGraw Hill, 1998). In 1996, the domestic adhesives and sealants industry exported \$202 million (actual dollars) worth of products to the rest of the world. Canada and Mexico remain the largest export markets.

In 1996, the United States exported \$212.8 million (actual dollars) worth of printing ink products. The fastest growing international market for this industry is Asia (DRI McGraw Hill, 1998).

F.7 Man-Made Fibers, Noncellulosic

The synthetic materials industry in the United States accounts for nearly 25 percent of the \$300 billion a year chemical industry; while man-made fibers contributed 6.25 percent to that total. SIC 2824 (NAICS code 325222), Organic Fibers (Noncellulosic), comprises 90 percent of total man-made fiber production. Organic fibers are used in products as varied as clothing and tires (Mote, 1994). These fibers are largely intermediate goods and are shipped to other manufacturers in the form of yarn, tow, staple, or monofilament. Thereafter, they are transformed into consumer and industrial products. In addition to being less expensive than natural fibers, synthetic fibers are also more durable, hold their shape better, and are more uniform.

The non-cellulosic, man-made organic fibers industry has experienced a mild roller coaster effect on its revenues in the last year. As shown in Table F-45, during the late 1980s, the synthetic fiber industry experienced steady growth. Between 1987 and 1989 the value of shipments grew 6.3 percent. However, that growth was negated during the recession in 1991 and 1992. The industry began recovering in 1993, and value of shipments rose by approximately 10.3 percent between 1991 and 1996, only to fall again in the following 2

Table F-45. Value of Shipments (1998 $$10^6$)

Year	SIC 2824 Man-Made Organic Fibers, Noncellulosic
1987	12,163.4
1988	12,430.3
1989	12,928.0
1990	12,446.3
1991	11,948.8
1992	12,084.1
1993	12,524.6
1994	12,922.7
1995	13,095.9
1996	13,175.5
1997	12,004.8

Sources: U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers.* Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999b. *1997 Census of Manufacturers, Industry Series: Noncellulosic Organic Fiber Manufacturing*. <http://www.census.gov/prod/www/abs/97ecmani.html>.

years to reach $12,004.8 million in 1997. All dollar values cited in this report are in constant 1998 dollars, unless otherwise indicated.[4]

[4]All values inflated using the plant cost index published in *Chemical Engineering*, various years.

F.7.1 Supply Side of the Industry

F.7.1.1 Production Processes

Man-made synthetic fibers are derived from both natural and petroleum-based ingredients that are melted together to form liquids containing free-moving molecules. The liquid passes through small holes in vats called spinnerets. As the liquid exits the vats, it hardens to form long filaments.

Manufacturers produce synthetic organic fibers using four variations of the process described above: dry, wet, melt, and core spinning. In dry spinning, the raw materials are dissolved in solvents. After passing through the spinnerets, the fibers-to-be are exposed to hot air. The solvents evaporate, leaving behind a solid filament.

Wet spinning is quite similar to dry spinning. The main difference between the two is that after the stream exits the vat through the spinneret, it falls into a coagulating chemical bath. As the stream enters the bath, it hardens, leaving a solid filament as the product.

Melt and core spinning are simple processes. In melt spinning, the raw materials are blended together and extruded. They dry upon contact with air to form the filaments. Core spinning involves spinning together a continuous filament yarn with a short-length hard fiber to form a composite. This is the newest method of production.

In all these processes, as the fiber is being spun it is manipulated to adopt various physical properties, such as drapability, softness, elasticity, stiffness, roughness, and resilience. After the spinning process, the fibers are stretched and oriented in preparation for dyeing, water resistance, stretch ability, and strength treatment. The product is then prepared for packaging and shipping.

F.7.1.2 Major By-products and Co-products

SIC 2824 has no co-products. Few by-products are associated with man-made fibers. Emissions from man-made fiber production are largely recovered by using activated carbon. However, no stringent air pollution controls are used, meaning that some carbon disulfide and hydrogen sulfide escape during production.

F.7.1.3 Types of Output

The man-made fiber industry produces fibers derived from molecules containing combinations of carbon, hydrogen, nitrogen, and oxygen. The output includes polyester, nylon, olefins, and acrylics.

These fibers are sold to manufacturers in four forms: yarn, monofilament, staple, and tow. Monofilaments are single, long strands used in toothbrushes and nylon stockings. Staple comprises fibers that are cut short. Staple is usually blended with other materials to form yarns. Tow is much like staple, but it is kept in long, rope-like form before being cut at a later time.

F.7.1.4 Costs of Production

New capital investments, increased productivity, and technology improvements have allowed the industry to cut its labor costs (Mote, 1994). The number of people employed by the man-made fiber industry has been reduced drastically over the past 15 years. In 1982, SIC 2824 employed over 60,000 people. By 1990, employment had dropped to 48,100. Since 1990, employment has further decreased by 11,000 jobs (23 percent) to level out at 37,100 jobs in 1997 (see Table F-46). Job-loss was concentrated in two areas: production-level positions and middle management. Increased automation, foreign competition, and new information technologies replaced human labor in these two areas. Over the period 1987 to 1997, the industry reduced its payroll 9.8 percent, from $1,602.0 million to $1,445.3 million. By comparison, the costs of materials fell by only 6.5 percent during the same period. The drop in costs is most likely because of the decline in the level of production. New capital investments averaged $762.8 million a year from 1987 to 1995. Investments contributed to the creation of new production strategies to help minimize increasing costs and make the production process more efficient (Mote, 1994). Energy costs averaged $455.8 million during the 1987 to 1997 period.

F.7.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of actual production level to the full production capacity level. Table F-47 presents the historical trends in the capacity

Table F-46. Inputs: Man-Made Fibers, Noncellulosic

Year	Labor: Quantity (10^3)	Labor: Payroll (1998 $$10^6$)	Materials (1998 $$10^6$)	New Capital Investment (1998 $$10^6$)	Energy (1998 $$10^6$)
SIC 2824 Man-Made Organic Fibers, Noncellulosic					
1987	45.4	1,602.0	6,142.6	552.2	491.4
1988	45.8	1,591.2	6,271.1	719.4	444.2
1989	48.0	1,644.6	6,445.5	756.8	467.1
1990	48.1	1,676.6	5,626.9	887.4	475.1
1991	46.9	1,691.1	5,299.6	873.4	446.8
1992	44.4	1,680.2	5,803.5	784.3	465.7
1993	42.3	1,600.0	6,016.9	999.1	516.2
1994	40.7	1,551.2	6,115.0	596.7	508.7
1995	38.6	1,469.9	6,508.0	696.3	478.9
1996	38.5	1,481.5	6,297.0	D	496.3
1997	37.1	1,445.3	5,743.9	NA	259.0[a]

Sources: U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990g. *1988 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992a. *1990 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999b. *1997 Census of Manufacturers, Industry Series: Noncellulosic Organic Fiber Manufacturing*. <http://www.census.gov/prod/www/abs/97ecmani.html>.

Table F-47. Capacity Utilization Ratios for SIC 2824

	1992	1993	1994	1995	1996	1997
SIC 2824	86	88	91	89	92	92

Source: U.S. Department of Commerce, Bureau of the Census. 1996. *Survey of Plant Capacity: 1994*. Washington, DC: Government Printing Office.

utilization for the man-made fibers industry. The full production capacity utilization ratio for the noncellulosic man-made fibers industry was 92 in 1997. Thus, plants manufacturing these fibers (SIC 2824) have been operating near full capacity.

F.7.2 Demand Side of the Industry

F.7.2.1 Product Characteristics

Man-made fibers are valued for their versatility and variety. They are less expensive than most natural fibers and are more durable and uniform. Used predominantly by the apparel and textile industry, synthetic fibers are flexible and resist aging and do not react to exposure to the elements. The fibers can be manipulated during the manufacturing process to become softer, rougher, stronger, or more resilient. They can be dyed and are easily woven to form other materials. Polyester and nylon are two key fibers produced by this industry. Polyester does not retain moisture, provides excellent electrical insulation, and is highly resistant to solvents. Nylon has a high strength-to-weight ratio, is not easily permanently deformed, and is resistant to abrasion.

F.7.2.2 Uses and Consumers of Products

The largest consumer of synthetic fibers is the floor-coverings industry. This sector consumes roughly 32 percent of all fibers produced to make floor coverings for residential, institutional, and industrial purposes. The apparel and various household textile industries consume about 25 percent and 10 percent respectively. The remainder is used in such varied industries as tires (for reinforcement), rope, surgical and sanitary supplies, fiberfill, electrical insulation, and plastics reinforcements.

Polyester fibers are used predominantly by the home furnishings and apparel industries, as well as general textile facilities. Nylon is mostly used in carpeting, but also in apparel, noncarpet home furnishings, ropes, and miscellaneous industrial products. Acrylics and olefins are used in apparel and highly durable carpeting, respectively. In response to increasing pressure from both the government and environmental groups, the industry is seeking methods for recycling fibers such as polyester into new fabrics and carpet materials.

F.7.2.3 Substitution Possibilities

Synthetic fibers were originally invented to provide the strength and durability that was lacking in natural fibers such as cotton and wool. Man-made fibers are also less expensive to produce. Natural fibers may be substituted for man-made ones in apparel, but these fibers do not have the same resistance to wear and tear that is necessary for use in tires, carpeting, meshes, and other products. Within the industry, polyester, acrylic, olefin, and nylon fibers have their own market segments. There is very little substitution between fibers because each fiber is valued for its unique properties. However, substitutions can occur between varying levels of quality and producers within each market segment. Table F-51 in Section 2.7.4 presents data on historical trends in consumption of man-made fibers.

F.7.3 Organization of the Industry

F.7.3.1 Firm Characteristics

Traditionally, the nature of the technology and capital costs associated with the manufacture of noncellulosic organic fibers permitted few firms to break into the market. However, between 1992 and 1997, some of those barriers broke down and the number of facilities in the industry increased. As shown in Table F-48, 67 companies operated 100 facilities producing noncellulosic organic fibers in 1997. By way of comparison, 42 companies produced noncellulosic organic fibers and operated 71 facilities in 1992, and 47 companies controlled 72 facilities in 1987.

The top five firms' sales was nearly four times that of the next five largest firms in 1992 (U.S. Department of Commerce, 1990f). However, facilities with 250 to nearly 2,500 employees experienced a decrease in their share of the total value of shipments from 95.4 percent in 1995 to 92.8 percent in 1997. During that period the number of firms employing fewer than 20 employees rose from three to 29.

The largest producers of man-made fibers are DuPont ($7,204.0 million), Hoescht Celanese ($6,906.0 million), Monsanto Company Chemical Group ($3,726.2 million), Mobile Chemical Company Inc. ($3,408.0 million), and ICI Americas ($3,300.0 million).

Table F-48. Size of Establishments and Value of Shipments for SIC 2824

Establishments With an Average of	1992 Number of Facilities	1992 Value of Shipments (1998 $\$10^6$)	1997 Number of Facilities	1997 Value of Shipments (1998 $\$10^6$)
1 to 4 employees	1	52.0	17	7.5
5 to 9 employees	0	0.0	3	6.3
10 to 19 employees	2	D	9	19.0
20 to 49 employees	7	D	6	41.6
50 to 99 employees	8	114.7	10	157.8
100 to 249 employees	14	386.8	17	574.9
250 to 499 employees	13	1,331.2	12	1,307.5
500 to 999 employees	6	989.4	12	2,665.7
1,000 to 2,499 employees	19	9,210.9	14	7,221.9
2,500 or more employees	1	D	-	D
Total	71	12,929.6	100	12,004.8

D = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990f. *1987 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999b. *1997 Census of Manufacturers, Industry Series: Noncellulosic Organic Fiber Manufacturing*. <http://www.census.gov/prod/www/abs/97ecmani.html>.

Market structure can affect the size and distribution of regulatory impacts; therefore, we examine the structure of the man-made fiber industry next. Concentration ratios are often used to evaluate the degree of competition in a market, with low concentration indicating the presence of a competitive market, and higher concentration suggesting less competitive markets. Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. Typical measures include four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indices (HHI). The CR4 for this industry in 1992 was 74, meaning that the top four firms accounted for 74 percent of the industry's total sales. The CR8 for the same year was 90. These ratios indicate that a few firms control a large share of the market. The highly concentrated nature of the man-made noncellulosic fibers industry is also indicated by its HHI of 2,158. According to the Department of Justice's (1992) Horizontal Merger Guidelines, industries with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). Table F-49 presents various measures of market concentration in the man-made fiber (noncellulosic) industry.

Table F-49. Measures of Market Concentration for SIC 2824: 1992

SIC	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2824	Man-Made Organic Fibers, Noncellulosic	74	90	2,158	42	71

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers*. Washington, DC: Government Printing Office.

F.7.3.2 Geographical Distribution

Table F-50 lists the top states in fiber production. The table lists only three states, illustrating the small number of players in this industry. While some small facilities also operate in other states, data were withheld from the 1992 Census of Manufactures to protect confidential business information. Among the states for which no information is disclosed, Delaware is the most notable. A DuPont facility in Delaware has the nation's largest share of the man-made fiber market and employs between 2,000 and 2,500 people.

The South is a major producer of man-made fibers. The two Carolinas alone account for 51.4 percent of the industry's total value of shipments and 47.5 percent of the industry's total employment. Of the 32 facilities in the Carolinas, only one has fewer than 20 employees. The average value of shipments of a fiber facility in Alabama is $158.8 million.

Table F-50. Industry Statistics for the Top Three States[a] for SIC 2824, 1992

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees	Number of Employees
South Carolina	3,438.0	18	0	11,900
North Carolina	2,773.6	14	1	9,200
Alabama	793.8	5	0	3,000
USA	12,084.8	71	3	44,400

[a] Data for other states, namely Delaware, are unavailable to protect confidentiality.

Source: U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers*. Washington, DC: Government Printing Office.

F.7.4 Markets and Trends

F.7.4.1 Production

Table F-51 presents statistics on the production and consumption of U.S. cellulosic fibers (SIC 2823) and noncellulosic fibers (SIC 2824), inclusive of the effects of international trade. Between 1987 and 1994, production slowed by 3.9 percent in terms of value of shipments, accompanying a 0.5 percent drop in consumption and a 61.9 percent drop in net exports.

Domestic. Domestic output fell by 3.9 percent between 1987 and 1994 in the face of competition from producers in emerging markets such as Asia and Latin America. However, U.S. corporations still control about 90 percent of the domestic market despite foreign competition.

Foreign. U.S. corporations controlled roughly 18 percent of the global market for man-made fibers in 1992. That figure was as high as 50 percent in 1950. In 1992, the United States imported nearly $900 million worth of man-made fibers. Fifty percent of the present

Table F-51. Production and Consumption of All Man-made Fibers: SICs 2823 and 2824 (1998 $\$10^6$)

Year	Domestic Production	Domestic Consumption	Net Exports
1987	14,383.2	13,591.5	791.8
1988	14,799.5	13,728.4	1,071.1
1989	15,513.4	14,494.8	1,018.6
1990	14,876.7	13,809.7	1,067.0
1991	13,853.3	12,851.2	1,002.1
1992	13,883.7	13,340.0	543.7
1993	14,087.6	13,604.2	483.4
1994	13,825.6	13,523.6	302.0

Note: Consumption = Domestic Production - Exports + Imports

Sources: U.S. Department of Commerce, International Trade Administration. 1989. *1989 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, International Trade Administration. 1993. *1994 U.S. Industrial Outlook*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

DRI McGraw Hill, Standard and Poor's and U.S. Department of Commerce, International Trade Administration. 1998. *U.S. Industry and Trade Outlook 1998*. New York: McGraw Hill.

worldwide capacity for polyester production is in Asia, compared to 13 percent in the United States.

F.7.4.2 Consumption

Domestic. The U.S. Department of Commerce expects the man-made fiber market to grow by 19 percent between 1995 and 2000. Consumption of polyester, the most popular fiber, is expected to increase 16 percent over the same period.

Foreign. The United States is the world's largest exporter of synthetic fibers, followed by Taiwan and Japan. Other significant exporters are Austria, Canada, and the Southeast Asian nations. The United States exported $1.7 billion (in nominal terms) in 1992, but producers from emerging countries such as Indonesia and China are increasing their share of the global market.

F.8 Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers

The Plastic Materials, Synthetic Resins, and Nonvulcanizable Elastomers industry is a relatively small organic chemical sector. In 1997, the sector (SIC 2821, NAICS 325211) shipped $49,282 million dollars worth of products. All dollar values are 1998 dollars unless otherwise indicated. This industry supplies essential products to major manufacturing and consumer industries from automobiles to home furnishings. Table F-52 shows value of shipments for SIC 2821. Over the period 1987 to 1997, shipments grew at an average rate of 8 percent per year.

Typical products manufactured by the industry include cellulose plastics materials, phenolic and other tar acid resins, urea and melamine resins, vinyl resins, styrene resins, alkyd resins, acrylic resins, poolyethylene resins, polypropylene resins, rosin modified resins, and other miscellaneous resins. SIC 2821 produces resins that are inputs into the production of fabricated plastics products or plastics film, sheet, rod, and other products. Production of fabricated plastic products and compounding of resins are classified as separate industries.

Plastic materials were first developed in the mid-1800s, with new resins being developed at an accelerated pace during the first half of the twentieth century. Most of the primary thermoplastic resins currently in use were developed during the period between 1900 and 1940**.** The advent of World War II brought plastics into great demand as substitutes for other materials that were in short supply, such as natural rubber.. During the decades following World War II, additional new resins were developed, and the introduction of alloys

Table F-52. Value (1998 $$10^6$) of Shipments

Year	SIC 2821
1987	$22,172.92
1988	$33,217.03
1989	$35,191.90
1990	$31,393.31
1991	$29,289.68
1992	$29,639.76
1993	$29,981.92
1994	$36,566.27
1995	$49,634.27
1996	$43,092.97
1997	$49,282.18

Prices adjusted using the PPI for SIC 2821.

Sources: U.S. Department of Commerce, Bureau of the Census. 1995g. *1992 Census of Manufactures, Industry Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995i. *1993 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1997a. *1995 Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. August 1997b. *1996 Current Industrial Reports: Paint, Varnish, and Lacquer*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1999h. *1997 Economic Census*. Washington, DC: Government Printing Office.

U.S. Bureau of Labor Statistics, Producer Price Index Revision—Current Series. Series ID PCU2821#. <http://www.bls.gov> Obtained August 18, 2000

and blends of various polymers made it possible to tailor properties to fit specific performance requirements. The demand for plastics increased steadily, as designers and engineers began to substitute plastics for other more traditional materials in production of automobiles, producer goods, and consumer goods (SPI, 1997).

F.8.1 Supply of Plastic Materials and Resins

F.8.1.1 Production Processes

Polymers and resins are generally produced through a polymerizing chemical reaction, with the specific chemical reagents depending on the specific resin to be produced. Acetal resins are produced by the polymerization of purified formaldehyde into both homo polymer and copolymer types. Amino resins include both melamine and urea resins. Melamine resins are formed by the condensation reaction of formaldehyde and melamine. Urea resins are formed by the condensation reaction of formaldehyde and urea. Phenolic resins were the first commercialized wholly synthetic polymer of plastic. The basic raw materials are formaldehyde and phenol.

F.8.1.2 Types of Output

Plastic resins can be divided, generally, into thermoset resins, which first liquify then harden in the presence of heat, and thermoplastic resins, which become pliable in the presence of heat. Thermosets include epoxy, polyester (unsaturated), urea and melamine, and phenolic resins. Thermoplastics include low density polyethylene, high density polyethylene, polypropylene, acrylonitrile-butadiene -styrene (ABS), Styrene-Acrylonitrile (SAN), polystyrene, nylon, polyvinyl chloride, thermoplastic polyester, and engineering resins. In 1997, total value of shipments for the industry (in 1998 dollars) was $49,282 million. Of that total, approximately $40,615 million (82 percent) were shipments of thermoplastic resins, and $8,229 million (18 percent) were shipments of thermosetting resins.

F.8.1.4 Costs of Production

The inputs for plastic materials and resins include raw materials, especially petrochemicals. Other inputs include labor and energy. In constant 1998 dollars, the cost of materials more than doubled over the period 1987 to 1997, as output also more than doubled (see Table F-53).

F.8.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio measures the ratio of actual operations to the full capacity production levels. Capacity utilization ranged between 84 percent and 89 percent over the period 1993 to 1998.

Table F-53. Inputs Used in Plastic Materials and Resins Industry

Year	Labor		Materials	New Capital	Energy
	Quantity (10^3)	Payroll (1998 $$10^6$)	Materials (1998 $$10^6$)	Investment (1998 $$10^6$)	Energy (1998 $$10^6$)
1987	56.3	1,694.555	13,019.13	1,053.669	NA
1988	58.3	2,244.724	20,000.48	1,661.1724	NA
1989	62	2,521.878	21,473.74	2,080.6125	NA
1990	62.4	2,491.057	19,432.69	2,441.8513	NA
1991	60.5	2,456.74	18,419.75	2,230.6712	NA
1992	60.4	2,529.575	17,838.26	1,616.5384	1,066.804
1993	62.2	2,660.542	18,533.98	1,830.4351	1,177.299
1994	69.2	3,116.056	21,701.4	2,527.3688	1,267.493
1995	70	3,782.761	29,966.59	2,654.4547	1,408.269
1996	58.6	3,078.084	26,684.04	2,991.5701	1,482.459
1997	61.035	3,464.973	28,089.96	NA	1,689.944

Prices adjusted using the PPI for SIC 2821.

F.8.2 Demand for Plastic Materials and Resins

Individual plastic materials and resins are valued because they have specific product characteristics that make them well suited for particular uses. Typically, plastic materials may be lighter, stronger, and/or more durable than some other traditional materials.

F.8.2.1 Uses and Consumers of Plastics

Plastic resins are processed by plastic fabricators into plastic materials, which them may be further processed prior to incorporation into final products. Major markets for plastic materials and resins include transportation, packaging, building and construction, electrical/electronics, furniture and finishings, consumer and institutional users, Industrial/machinery, adhesives/inks/coatings. Table F-54 shows total resin use by major market over the period 1992 to 1996. Overall, plastic sales and use grew by an average of five percent per year over the period, with even faster growth occurring in the transportation, building and construction, furniture and furnishings, and industrial/machinery markets.

Table F-54. Total Resin Sales and Captive Use by Major Market (millions of pounds, dry weight basis)

Major Market	Year 1992	1993	1994	1995	1996	Growth Rates
Transportation	2,817	3,221	3,795	3,916	3,964	0.0683162
Packaging	18,284	19,569	19,551	19,334	21,271	0.0302637
Building and Construction	11,876	12,885	14,715	14,321	16,199	0.062086
Electrical/electronic	2,766	2,981	3,325	2,966	3,137	0.0251729
Furniture and Furnishings	2,559	2,759	3,118	3,198	3,477	0.0613107
Consumer and Institutional Uses	6,093	6,015	9,266	9,054	9,804	0.09513
Industrial/machinery	671	768	836	818	980	0.0757567
Adhesives/Inks/Coatings	1,723	1,572	1,789	1,795	1,833	0.0123774
All Other	6,877	7,234	7,515	8,050	9,361	0.0616739
Exports	6,950	6,632	6,889	7,742	8,722	0.0454214
Total	60,562	63,636	70,799	71,194	78,748	0.052517

Prices adjusted using the PPI for SIC 2821.
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F.8.2.2 Substitution Possibilities

Substitutes for plastics include all traditional materials. Substitutes for specific resins include other resins as well as traditional materials. Because plastics are formulated and compounded to have specific properties demanded for particular uses, other materials are imperfect substitutes for specific resins. Holding other things equal, this would tend to make demand for specific plastic resins somewhat inelastic.

F.8.3 Organization of the Industry

F.8.3.1 Firm Characteristics

As shown in Table F-55, in 1997 and in 1992, the largest number of plastics establishments had between 20 and 49 employees. However, the largest share of the industry's value of shipments was produced by establishments with between 100 and 249

Table F-55. Size of Establishments and Value of Shipments for SIC 2821, 1997

Employment Size Category	1992 Number of Establishments	1992 Value of Shipments by Employment Size (1998 $\$10^6$)	1997 Number of Establishments	1997 Value of Shipments by Employment Size (1998 $\$10^6$)
1 to 4 employees	26	27.26897	21	13.586761
5 to 9 employees	36	86.44641	38	186.31629
10 to 19 employees	47	266.0618	56	539.03364
20 to 49 employees	110	1,376.325	160	3,417.6524
50 to 99 employees	101	3,888.289	114	5,958.2407
100 to 249 employees	72	6,627.684	94	13,837.611
250 to 499 employees	30	5,150.71	28	8,971.3418
500 to 1,000 employees	19	6,657.131	14	7,968.8801
over 1,000 employees	8	a	7	a
Total	449	29,639.76	532	49,282.185

Prices adjusted using the PPI for SIC 2821.

[a] Not shown to avoid revealing company-specific data. Data are included in totals.

employees. More than 75 percent of the value of shipments is produced by establishments having more than 100 employees. This suggests that the industry is somewhat dominated by large plants.

The four- and eight-firm concentration ratios (CR4 and CR8) and HHI are used to assess the market structure of an industry. The CR4 for the plastic materials and resins industry was 24 in 1992, meaning that the top four firms accounted for only 24 percent of the industry's total sales. The CR8 for the same year was 39 (U.S. Department of Justice, 1992). This indicates that the plastic materials and resins market is fairly competitive. Furthermore, the HHI for the plastic materials and resins industry was 284 in 1992. According to the Department of Justice's (1992) Horizontal Merger Guidelines, industries with HHIs below 1,000 are considered to be unconcentrated (i.e., more competitive). Therefore, firms in the plastics and resins industry are more likely to be price takers. Table F-56 shows the CR4, CR8, HHI, number of companies, and number of facilities data for SIC 2821 for 1992.

Table F-56. Measures of Market Concentration by SIC: 1992

SIC	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
SIC 2821	Plastic materials and resins	24	39	284	241	449

Source: U.S. Department of Commerce, Bureau of the Census. 1995a. *Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

F.8.3.2 Geographical Distribution

Texas dominates the production of plastic materials and resins. As shown in Table F-57, Texas has more than twice as many facilities, twice as much output, and twice as many employees in the industry as the next largest states. With 68 plants, Texas has more than 12 percent of the total 532 plastic materials facilities in the country. Other states with a large number of facilities or a large value of shipments include two of Texas' neighbors, Oklahoma and Louisiana, as well as Kentucky and Indiana.

Table F-57. Industry Statistics for the Top Ten States for SIC 2821, 1997

State	Value of Shipments (1998 $\$10^6$)	Number of Facilities	Facilities With Fewer Than 20 Employees	Number of Employees
Texas	$16,050.4	68	53	12,920
Louisiana	$6,617.3	21	19	5,152
Kentucky	$2,822.0	14	13	2,986
Oklahoma	$1,834.5	34	29	3,088
Indiana	$1,656.7	15	13	2,711

Prices adjusted using the PPI for SIC 2821.

Source: U.S. Department of Commerce, Bureau of the Census. 1999h. *1997 Economic Census*. Washington, DC: Government Printing Office.

F.8.4 Markets and Trends

Table F-58 shows production and consumption trends for the period 1992 to 1997. There has been considerable growth in the production and consumption of plastics during the period. From 1992 to 1997, both production and consumption grew at an average rate exceeding 9 percent per year. Exports and imports both more than doubled during the period, with net exports being positive and growing, so that domestic production exceeded domestic consumption by a growing margin.

Table F-58. Production and Consumption Trends for SIC 2821, 1992 to 1997 (1998 $\$10^6$)

Year	Domestic Production	Value of Imports	Value of Exports	Apparent Consumption
1992	31,528.795	2,032.864	6,714.036	26,847.622
1993	31,924.028	2,476.823	6,919.138	27,481.713
1994	37,633.054	3,343.578	8,437.093	32,539.539
1995	50,278.039	4,797.414	11,948.99	43,126.466
1996	45,945.04	4,633.086	11,504.8	39,073.328
1997	50,492.909	5,293.629	13,138.99	42,647.547

Prices adjusted using the PPI for SIC 2821.

F.8.4.1 Production

Domestic. Domestic production grew from $31.5 billion to $50.5 billion during the 5 years from 1992 to 1997. Production grew at an annual rate of more than 9 percent over the 5-year period, with a 1-year downturn in 1996.

Foreign. Foreign plastic materials producers increased their sales to the United States during the period. In 1997, U.S. imports were $5.2 billion.

F.8.4.2 Consumption

Domestic. Domestic consumption grew at an annual rate of more than 9 percent over the period from 1992 to 1997, with a 1-year downturn in 1996.

Foreign. In 1997, U.S. plastic materials producers exported \$13.1 billion of plastic resins to NAFTA countries, western Europe, and Asia.

F.8.4.3 Trends

For the near term, 2000-2004, the outlook for plastics will continue to be favorable, with constant dollar shipments growing between 3 and 4 percent per year. A somewhat weaker domestic economy is projected to reduce consumption in some key end-use markets, including construction and transportation. However, economic recoveries in Asia and Latin America are projected to somewhat offset the slowing domestic demand (McGraw-Hill, U.S. Department of Commerce, 2000).

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16. ABSTRACT

This report presents a technical analysis of the economic impacts associated with the proposed Miscellaneous Organic NESHAP (MON). The analysis evaluates adjustments in the markets for various organic chemical and coating products (through price and production changes), social cost, and the resulting affects on employment and small businesses.

17. KEY WORDS AND DOCUMENT ANALYSIS

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